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APPLICATION NUMBER: *09/504,853*

10/069234

FILING DATE: *February 16, 2000*

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Case Docket No.: 74/60

Sir,

Transmitted herewith for filing is the patent application of

Inventor: DAVID KONOPNICKI, LIOR LEIBA, ODED SHIVUELI AND YEHOSHUA SAGIV

For : SYSTEM AND METHOD FOR AUTOMATED CONTRACT FORMATION

Enclosed are:

- ☒ 8 sheets of formal drawing(s).
- x An assignment of the invention to TECHN'ON
- ☐ A certified copy of a _____ application
- ☐ An associate power of attorney
- X A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27.
- ☐ Other - _____

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Respectfully,

Mark M. Friedman
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NON-PROFIT ORGANIZATION - NEW APPLICATION

Attorney Docket No.: 74/80

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In RE Application of: DAVID KONOPNICKI, IHOR LEVA, ODED SHMUELI AND YEHOSHUA SAGIV

Filed Concurrently Herewith

For: SYSTEM AND METHOD FOR AUTOMATED CONTRACT FORMATION

VERIFIED STATEMENT UNDER 37 CFR 1.27
CLAIMING STATUS AS A SMALL ENTITY

To The Commissioner of Patents and Trademarks:

I hereby declare that

I am an official empowered to act on behalf of the nonprofit organization identified below:

Name of Organization : Technion R & D Foundation Ltd.

Address : Gutwirth Science Park, Technion City, Haifa 32000, Israel

The above organization is a UNIVERSITY OR OTHER INSTITUTION OF HIGHER EDUCATION

I hereby declare that the nonprofit organization identified above qualifies as a nonprofit organization as defined in 37 CFR 1.9(e) for purposes of paying reduced fees under 35 USC § 41(a) and § 41(b) to the Patent and Trademark Office with regard to the above-entitled invention described in the specification filed herewith.

Rights under contract or law have been conveyed to and remain with the nonprofit organization identified above with regard to the above entitled invention.

If the rights held by the nonprofit organization are not exclusive, each other party having rights to the invention is listed below, and no rights to the invention are held by any party who could not qualify as a small entity under 37 CFR 1.9(f), namely any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

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Address : _____

Status : ☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

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Address : _____

Status : ☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

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Technion R & D Foundation Ltd.
Technion City - Haifa 32000, Israel

Name of Person Signing: AVISHAI TZUR

Signature: _____ Date: 2. FEB. 2000

DIRECTOR
BUSINESS DEVELOPMENT & FINANCIAL CONTROL DIVISION

Capacity of Person Signing: _____

Address of Person Signing: 35 ASHER BARASH ST.
HERZELYA, ISRAEL

Ran Kobo
Managing Director

APPLICATION FOR PATENT

Title: SYSTEM AND METHOD FOR AUTOMATED CONTRACT FORMATION

Inventors: David Konopnicki, Lior Leiba, Oded Shmueli and Yehoshua Sagiv

This Application claims priority from U.S. Provisional Application No. 60/151,795, filed on August 31, 1999, which is pending.

FIELD AND BACKGROUND OF THE PRESENT INVENTION

The present invention is of a system and method for automated and semi-automated contract formation, and in particular, for automated negotiations which lead to the construction of a contract between two parties.

E-commerce (electronic commerce) is an increasingly popular type of business activity. The term "e-commerce" refers to business activities conducted through the Internet, and in particular through Web sites on the World-Wide Web (WWW). The amount of merchandise sold on the World Wide Web is constantly growing, including products and services which range from the delivery of flowers to the purchase of books and computer hardware. The current architecture for e-commerce on the Web mainly relies upon a Web page-based interface, which is navigated by using the Web browser of the user. Such an architecture has several disadvantages.

First, each vendor must establish a separate, non-standardized, Web site. Therefore, each vendor must rely upon its own technology and non-standardized interface, which is inefficient and time consuming for the vendor. **Second**, the requirement to navigate through Web sites with a Web browser is inefficient for the user, or potential customer, who may wish to consider only specific products and/or services. **Third**, there is no standard for conducting automatic negotiations in either business-to-business (B2B) or business-to-consumer (B2C) settings (some sites do offer ad-hoc negotiations, for example "Hagglezone" [*http://www.hagglezone.com* as of January 2, 2000] and to a limited extent "Priceline" [*http://www.priceline.com* as of January 2, 2000]. In addition, there are also auctions which offer a form of negotiation as in "eBay" [*http://www.ebay.com* as of January 2, 2000]). **Fourth**, there are no facilities and standards for conducting negotiations on package deals, such that most commerce is on single items or a collection of items (also called a basket or a shopping cart) in which each item is considered in isolation (for example *http://www.buywiz.com*).

One attempted solution to these problems is the provision of automated agents, known as "shopbots", which navigate through a plurality of Web sites in an attempt to locate products and/or services which fit certain parameters specified by the user. For example, such an automated agent may optionally be used to locate a product within a certain price range. Although the automated agent enables the user to consider products from a plurality of Web sites according to one or more specific criteria, the user is still required to navigate through the Web

site of the vendor in order to actually purchase the product. Examples of such automated agents include "R U Sure" [*http://www.rusure.com* as of January 2 2000], and "BuyWiz" [*http://www.buywiz.com* as of January 2 2000] which are agents for buying goods, as well as various types of information brokers, which retrieve information about products and services through the Internet [1]. Such systems are generally task-oriented and do not define a general framework for negotiation. Thus, this attempted solution does not address the previously described disadvantages.

Other examples of attempted solutions for the specific problems of negotiation are described in "Agents as Mediators in Electronic Commerce" [2]. For example "AuctionBot" describes an automated auction server, which permits the seller to select from various predetermined protocols for conducting an auction. However, the protocols cannot be flexibly determined during the auction itself. Similarly, "Kasbah" is a Web-based multiagent classified ad system which offers very limited negotiation features, related to the rate with which a buyer increases a bid to a seller over time. "Tete-a-Tete" is a system which provides more flexibility, in that terms other than price can be negotiated, but the negotiation features which are provided are still very limited.

A more preferred solution would provide automated or semi-automated processes for e-commerce, which are still sufficiently flexible to meet the needs of users. These processes would require that the Web sites of vendors become machine-interactable, or capable of interaction with automated tools (software

programs). In addition, these Web sites should become machine-analyzable, or capable of being analyzed by these automated tools. The machine-interactability and analyzability properties of these Web sites would enable the process of e-commerce to become automated or at least semi-automated, thereby becoming more efficient and simpler for the user to operate. Furthermore, the automation or semi-automation of these processes would enable the user to locate vendors of interest more quickly, and with a greater likelihood of successful matching between the needs of the user and the characteristics of the vendor.

One attempt to provide such a solution is described in an article by S. Bottcher [3], which addresses the need for searching for a business partner in a distributed electronic market. This article discloses the use of a static tree in order to match potential customers to vendors of interest. The advantage of the static tree is that it provides greater flexibility than simple string-based matching, such as that performed by many Internet search engines. The disadvantage of the static tree is that it cannot be used for negotiations or for dynamic matching, since the tree itself cannot be adjusted. Since interactions between a potential customer and a vendor are typically a dynamic process, in which the vendor provides a description of available goods and/or services, and the potential customer then considers whether to make a purchase from the vendor, the use of a static tree is ultimately limiting.

A more useful approach would involve the use of dynamic trees which can be adjusted, or even created, "on the fly" during the course of the negotiations.

The trees are only partially defined for initiating the process of negotiation. As the process continues, the trees are constructed, thereby enabling the process of negotiations to be conducted flexibly and dynamically. Furthermore, these data structures enable the ultimate resolution of the process of negotiation to be expressed as a contract, since the dynamically constructed trees are then converted into a language-based description. Unfortunately, such a solution is not available.

There is thus a need for, and it would be useful to have, a system and a method for automated or at least semi-automated, dynamic negotiation between a potential customer and a vendor, in which the Web site of the vendor is capable of interacting with software-based automated tools, and in which the process of negotiation involves the construction of a tree "on the fly", which can then be expressed as a natural language-based description for the determination of a contract between the parties.

SUMMARY OF THE INVENTION

The present invention is of a system and method for the automated, or at least semi-automated, process of negotiation between a potential customer and a vendor through software tools, for example at a Web site, although optionally through computational devices connected by any network. The process of negotiation, if successful, results in the construction of a contract between the parties.

According to the present invention, there is provided a method for at least semi-automatically negotiating a relationship between at least a first party and a second party, the steps of the method being performed by a data processor, the method comprising the steps of: (a) providing a first intention for the first party and a second intention for the second party, each of the first intention and the second intention featuring a plurality of components; (b) exchanging at least one dispatch between the first party and the second party, the at least one dispatch including a value for at least one of the plurality of components; (c) altering at least one of the first intention for the first party and the second intention for the second party according to the value in the at least one dispatch; (d) comparing the first intention to the second intention; and (e) if the first intention matches the second intention, determining the relationship according to the first intention and the second intention.

According to another embodiment of the present invention, there is provided a system for at least semi-automatically negotiating a relationship, the system comprising: (a) a plurality of party modules, including at least a first party module and a second party module, each party module featuring an intention for determining the relationship, the intention featuring a plurality of components to be determined for the relationship, such that a process of negotiation matches the intention of the first party module to the intention of the second party module; and (b) a central server for initially connecting the first party module to the second party module for performing negotiations.

Hereinafter, the term "network" refers to a connection between any two or more computational devices which permits the transmission of data.

Hereinafter, the term "computer" includes, but is not limited to, personal computers (PC) having an operating system such as DOS, Windows™, OS/2™ or Linux; Macintosh™ computers; computers having JAVA™-OS as the operating system; graphical workstations such as the computers of Sun Microsystems™ and Silicon Graphics™, and other computers having some version of the UNIX operating system such as AIX™ or SOLARIS™ of Sun Microsystems™; or any other known and available operating system, or any device, including but not limited to: laptops, hand-held computers, enhanced cellular telephones, wearable computers of any sort, which can be connected to a network as previously defined and which has an operating system, as well as electronic or biological hardware, systems, servers and the like. Hereinafter, the term "Windows™" includes but is not limited to Windows95™, Windows 3.x™ in which "x" is an integer such as "1", Windows NT™, Windows98™, Windows CE™, Windows2000™, and any upgraded versions of these operating systems by Microsoft Corp. (USA).

Examples of a "computational device" include, but are not limited to, a computer as defined above, or an independently operated software module or agent in any suitable programming language.

Hereinafter, the term "semi-automatic" refers to a process in which a human decision maker participates in the negotiation/decision phases of a

commercial activity.

The method of the present invention could be described as a series of steps performed by a data processor, and as such could optionally be implemented as software, hardware or firmware, or a combination thereof. For the present invention, a software application could be written in substantially any suitable programming language, which could easily be selected by one of ordinary skill in the art. The programming language chosen should be compatible with the computer according to which the software application is executed. Examples of suitable programming languages include, but are not limited to, C, C++, Visual Basic, Prolog, Lisp, ML and Java.

GLOSSARY

EC Party: A legal entity that may be involved in a deal. In particular, it can designate individuals, corporations, countries, state and local authorities, organizations and associations.

Intention: A specification of a deal. In particular, it can designate the objectives of the deal (e.g., buy, rent), parties and objects involved in the deal, and constraints involving these entities.

Component: A component is an entity that is a building block for intentions.

Atomic component: A component describing a simple entity such as a bit, a number or a string.

Compound component: A component that is built of other components.

Constraint component: A component describing constraints on other components, e.g. that one atomic component is larger than another.

Basic component: A component whose structure is known to a user community and is agreed upon as representing a real life concept. Basic components are named.

Variable component: A component that is represented by a variable.

Computable variable component: A variable component that is associated with one or more computational devices. Such a device transforms that variable into a component. This component usually includes further elaboration on the deal.

Dispatch: Any information communicated from one party to another party, including but not limited to, an intention, a component or a portion thereof, or questions about intentions or components.

Fitting: A process of taking one or more intentions and reconciling them into intentions that together satisfy as much as possible the constraints prescribed by the original set of intentions.

Contract: A set of intentions that are agreed upon by the issuing parties. In particular, if that set consisting of one intention it's called a **simple contract**. If it includes no variable components it is called a **ground contract**.

Atomic value: a concrete representation of an atomic component.

Atomic type: A set of atomic values.

Class: a prototype of a compound component, for example a class in Java

or C++, a compound term in logic programming (Prolog), a list structure in LISP, etc. The specification of a class can involve atomic types, values and classes. A class usually has a **name**.

Class value: a particular instance of a class prototype.

Basic class: A class that constitutes a basic component.

Variable: An entity with a name, a type (atomic, class, atomic collection, class collection where a collection is, e.g., list, set, subset, superset, one-of, array) and value (either atomic value, class value, undefined (called **null**), or a collection of values.)

Computable variable: A variable that is specified to be a computable component.

Reference to a value: This term refers to one of the following items - the value itself, a request for the value, or a set of values from which one value is to be selected.

Abstract class: A class that has a name but no class instances. It is used to abstract classes that appear in a class hierarchy (see below).

Sub-class relationship: A statement that a class, say A, is more general than a class, say B. Classes A and B need not have similar prototypes. Classes may be abstract.

Class hierarchy: A collection of sub-class relationships. It is sometimes required that this relationship be transitively non-cyclic, i.e., that a class is not its own subclass.

Ontology: A collection of class hierarchies. It is sometimes required that no class name appears in more than one hierarchy of the ontology.

Item ontology: A particular ontology that usually contains names of basic classes that correspond to objects or concepts, for example car, bank account, John, Pepsi Co..

General ontology: A particular ontology that usually contains names of basic classes that correspond to transactions, for example buy, rent, lease, transport, invest, destroy, build.

Party information: A set of information items an EC party maintains. This set usually contains its identity, a collection of intentions, and other data relevant to its operation. The party information may change dynamically over time. Parts of it may be published for outsiders to access/view and parts of it may be restricted in terms of who and when can access/view them.

Operator class: A class that indicates constraints on values. Examples are OR, AND, NOT and ONE-OF.

Intention trees: An intention built by the following process. One starts with an instance of a general class, i.e., one belonging to the general ontology, and then may extend it via zero or more extension steps.

Extension step: An extension step is performed by: replacing a null atomic variable by an atomic value, or by replacing a null class variable with a new fresh copy of a class prototype, or by replacing a null collection variable by a collection of values, or by introducing an operator class instance and modifying the intention

in accordance to rules of introduction of operator classes.

Constraint: A constraint component specifying limitations on values variables may be associated with, on relationships concerning variables and values, and on aggregates of values.

Message: Communication of information between one or more computational devices.

Reply: A message that is sent as a response to another message or messages.

Relation: A form of representing a collection of information items, each item is composed of fields and values for these fields.

Commerce automaton: A computational device that is specified using states, transitions among states, predicates (i.e., conditions) on transitions, actions to be performed in a state, the forms of input, the forms of output. In particular, actions may be the sending or receiving of messages and creation/destruction/access/modification of values of variables including variables associated with relations and other relations (e.g., those associated with party information). A computable variable component is associated with one or more commerce automata, although preferably the variable component is associated with a single commerce automaton.

Negotiation automaton: A computational device used to answer messages that are generated by commerce automata. The exact internal structure of the NA may optionally be unspecified. Optionally the NA may resemble a CA, and

alternatively it may be a program implemented via any language on any computer. The implementation may also optionally include manual answers. As explained below, a negotiation automaton is conceptually associated with every atomic component, basic component, and compound component, as well as every vertex in an intention tree.

Unification of intention trees: The fitting of intention trees. The process optionally involves matching of similar components, the assignment of values to variables, the execution and/or analysis of commerce automata, exchange of messages. The result is one or more intention trees that satisfy as much as possible the constraints expressed by the original intention trees. If the parties, that present the original intention trees, agree upon the result, an **electronic contract (EContract)** is said to result. The EContract is **ground** if all variables are assigned non-null values. The EContract variables may be associated with party or parties that are to determine their actual values at the point of execution of deal(s). The EContract is **single** if it consists of a single intention.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, wherein:

FIGS. 1A-1D are examples of classes, presented as trees, according to the present invention;

FIGS. 2A-2D are variable instantiations according to the present invention;

FIGS. 3A and 3B describes adding operator vertices according to the present invention;

FIG. 4 describes a process of using operator vertices according to the present invention;

FIGS. 5A-5C describe exemplary commerce automata according to the present invention;

FIG. 6 describes an exemplary commercial automaton according to the present invention;

FIG. 7 is an exemplary intention tree of a customer;

FIG. 8 is an exemplary intention tree of a vendor;

FIG. 9 is an exemplary unified intention tree as an EContract;

FIG. 10 is a schematic block diagram of an implementation of the present invention;

FIG. 11 is a schematic block diagram of an exemplary party architecture according to the present invention; and

FIG. 12 is a flowchart of a method according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a system and method for the automated, or at least semi-automated, process of negotiation between a potential customer and a vendor through software tools, for example at a Web site, although optionally

through computational devices connected by any network. The process of negotiation, if successful, results in the construction of a contract between the parties.

The *EContracts framework* is a preferred implementation of the present invention, which enables e-commerce WWW sites and e-commerce automated tools to present standardized information. This information (1) allows each party to decide whether it wishes to engage in an e-commerce activity with the other party, (2) enables automated negotiation between the parties, and (3) enables the establishment of an *electronic contract*, i.e., a formal description of an agreed upon e-commerce transaction. The EContracts framework defines the basic software components of an e-commerce party and their interconnections. Based on the EContracts framework, various applications can be built. Examples are deal making applications, deal feasibility checkers, brokers and so forth.

The system and method of the present invention have a number of advantages over the background art. First, entire negotiated agreements, which could be termed a package deal, or contracts can be specified, rather than a single product or "shopping baskets", which are simply collections of products. This advantage is significant, as it enables complex relationships between parties to be negotiated and specified.

Second, this formalism is particularly suited for automatic or semi-automatic negotiations which seek to match, at least partially, the preferences and requirements of each party.

Third, the negotiated agreement or contract can optionally specify a symmetric relationship, rather than simply determining the exchange of money for a product. For example, the relationship could involve the exchange of items. Such a symmetric relationship cannot be determined with the automated agents or other automated tools of the background art, which are designed primarily for the exchange of money for products.

Fourth, the products themselves can be complex, for example involving multiple parameters and options. The products may be particularly complex for business-to-business relationships, in which the products may be a combination of goods and services, for example. As another example of complex products, the product may optionally be an option on two airline tickets in January to a particular city.

Fifth, the present invention enables business rules and data to optionally be exposed only to a desired level. For example, a bank could optionally show interest rates for deposits of up to one million dollars, but not for higher amounts. Also, the level of exposure can be adjusted for negotiation with each party, such that different levels of exposure may optionally be adopted for business-to-business negotiations, as opposed to negotiations with consumers, for example.

Sixth, contracts and/or agreements are specified formally, and hence are more difficult to dispute. The building blocks of contracts can be analyzed in advance by legal authors and experts to verify their compliance with various laws.

Seventh, the formalism presented below is optionally extendible to new

market segments, new products and new types of agreements or business relationships.

Eighth, the agreement can easily be expressed in natural language.

Certain of these concepts were briefly explored in two papers: D. Konopnicki, L. Leiba, O. Shmueli, and Y. Sagiv; "Toward automated electronic commerce"; In First IAC Workshop on Internet-Based Negotiation Technologies; IBM TJ Watson Research Center, Yorktown Heights, NY; March 1999; and D. Konopnicki, L. Leiba, O. Shmueli, and Y. Sagiv; "A Formal Yet Practical Approach To Electronic Commerce"; In Proc. COOPIS '99, Edinburgh, Scotland, September 1999. However, the former paper in particular did not include the detailed, complete realization of the present invention as described herein.

The subsequent description is organized as follows. Section 1 is an introduction to the basic concepts of the present invention, to the goals of operating the present invention, and to the basic architecture of an automatic negotiating tool. Section 2 presents the basic terminology of EContracts. Section 3 defines intentions. In particular, it presents the commerce automata formalism and the way parties exchange messages during negotiations. Section 4 discusses unification, as well as upgraded unification that allows to perform unification by relaxing certain constraints. Section 5 presents examples of specific embodiments of the present invention.

Section 1: Introduction

Structuring Electronic Commerce (EC) is expected to be the main activity on the Internet, private networks and the WWW. A universal formalism ("the HTML of EC") is required, which supports business relationships and negotiations on a global scale, as well as protocols which support automatic tools (agents). The present invention provides such a formalism by enabling parties to specify *intentions*, a formal outline of deals in which such parties are ready to engage. Intentions are made of *components*.

Components may be atomic or compound (to any required depth). Furthermore, a component may be a *variable component*, that is unspecified, or alternatively is specified only according to its type (see below for an explanation of types of components). Components may also be inter-related (e.g., by containment, by edge or labeled-edge connection, or by arbitrary predicates). An important facet of a variable component is its possible association with one or more computational devices, although one-to-one association of a variable component with a computational device is particularly preferred, and is described herein. Such a computational device, based on its perceived state and messages, transforms a variable component into a component. The term "perceived state" is intended to include inputs, values of various components, values of certain other entities such as files, databases and the like. The "new" component is usually "more specific" than the variable component it replaces. According to the present invention, such variable components and their associated computational devices

embody transient or policy dependent aspects of the willingness to engage in a deal. It is desirable, although not mandatory, that the functionality of the computational device be readily understood by inspection, a property termed herein *analyzability*.

Forming an agreement, or negotiating a contract, requires the reconciliation of the constraints placed on deals by the (two or more) parties involved. For simplicity, the present invention is described with regard to two parties, it being understood that the concepts presented herein are easily generalized to multi-party scenarios. Reconciliation involves forming an agreement or contract which, as much as possible, is subject to the directives of the parties, as well as to any general laws which may apply. When examining two intentions, the process of reconciling the constraints may be considered to be a form of "fitting" to these constraints. Abstractly, this process fits the component structure of one party with the corresponding components of the other party.

Each party is assumed to employ a computational entity, or "party machine" (PM), which controls the fitting of intentions. The PM may communicate with other computational devices, and in particular other PMs, in attaining its mission. For example, it may be responsible for activating the "fitting process" or activating the computational device associated with a variable component.

There are some very basic requirements for automated or, at least semi-automated electronic commerce. First, a common terminology for intentions is

needed. The analogy here is the natural language used by humans, suitably formalized, for commercial activities, such that the intentions of a party can be readily understood by other parties. Second, a mutually agreeable architecture is needed so that a PM of a party can assume certain abilities of a PM of another party. An analogy here is the client-server architecture of the WWW. Third, as stated, computational devices may issue messages and require responses, which would form a foundation for automated, or semi-automated, negotiations. So, a protocol for negotiations needs to be established for operation with the automated tools, similar to those protocols exercised as part of human behavior in commercial negotiations.

In designing solutions for the above mentioned three requirements, a number of properties are desirable. The common terminology should be simple, yet expressive and powerful. The architecture should be modular and orthogonal, i.e , different modules should address different concerns. To enable a rich set of commerce modes, the structure and content of e-commerce parties should be machine-analyzable. Machine analyzability gives rise to greater efficiency as well (see below). Of course, an e-commerce party should be able to have opaque portions that are not viewable by other parties, and/or with a level of visibility to other parties or classes of parties which is controllable by the owner of the party.

Using these concepts, various applications can be built, as described in greater detail below. Although a particular implementation of these concepts is described herein, it should be noted that other realizations of these concepts are

possible. In particular, as described below the present invention is implemented with a programming logic which is similar to that of the Prolog programming language and logic programming. Other implementations may rely on LISP and functional programming, on more natural language oriented formalisms, on Java, C++ and Object Oriented formalisms and many more, such that the description of the preferred embodiments below is not intended to be limiting in any way.

According to the present invention, a number of mechanisms must be implemented for the process of negotiations to be conducted with automated or semi-automated tools. The first step is to ensure that intentions are universally understood. In EContracts, a component is represented as a *rooted labeled tree*. In fact, an intention is also a rooted labeled tree which is composed of components, together with various constraints and computational devices. The most basic components are *simple atomic entities*, e.g., of type integer, float, string. Next are *basic components* that are essentially (usually small) trees whose structure is agreed upon to represent a concept (e.g. car, sale, address). These basic components are called *classes* and they form the "words" of the common language. The word "class" hints at the fact that in an object-oriented realization, these components are likely to be represented as object oriented classes, although the present invention is not limited to such a representation. A component may be a *variable component*. In this case it appears as a single node labeled with a typed variable. Such a type may be atomic, atomic list, class or list of classes. Such a variable component cannot exist in isolation but must be a leaf of a class.

Using classes, the parties compose their intentions, essentially forming "sentences" which in turn define possible deals. As noted, the purpose of an intention is to describe a deal that a party is willing to engage in. For example, an intention can express that the *BooksOnline Corp. is selling books and that if you buy more than five books, you receive a 10% discount.* In EContracts, the mechanism that composes words into sentences, or classes into intentions, relies on "variable instantiation" and the introduction of "operator nodes". A (leaf) variable component of an intention is optionally and preferably associated with a computation device, called a "commerce automaton" (CA) in this realization, which prescribes how the variable may be instantiated further during a later phase. A commerce automaton may outline a message exchange sequence between the parties. However, it should be noted that a commerce automaton, and the related entity, the "negotiation automaton" (NA, described in greater detail below), are only one realization of a device or entity for exchanging messages between the parties according to the present invention, and is in no way limiting. In addition to intentions, an e-commerce party also maintains *party information*, a database or file containing information relevant to the party's activities. This is part of the "system state".

A deal is manifested by creating a mutually agreed upon *electronic contract* (EContract). The process of obtaining an EContract begins with two initial intentions, presented by the parties. A formal process, called *unification*, a part of the realization of "fitting", is used to construct an agreed upon EContract,

provided such a contract is feasible. Unification may also be used by an e-commerce party to determine whether an EContract is at all possible, prior to entering actual negotiations with the other party, hence the importance and desirability of machine analyzability.

The EContract framework defines the basic software components of an e-commerce party and their interconnections. Each party features a party machine, described in greater detail below with regard to Section 5. The party machine in turn has a number of associated data structures, including a party information data structure and an intentions data structure.

The party information data structure is preferably constructed as a standard relational database which contains the global data of the party machine, such as item lists, pricing information and so forth. This global data is described in greater detail below with regard to Sections 2 and 5. Optionally, at least a portion of the party information data structure may be queried by other party machines, although preferably, a least a portion of party information data structure is opaque, or not accessible, to other party machines. More preferably, the party information data structure includes data which defines the legal status of the party which operates party machine, such as the name, address and telephone number, for example, of the party which operates the party machine.

The intentions data structure preferably defines business goals, expressed as a plurality of intentions. These intentions are described in greater detail below with regard to Sections 3 and 5. Intentions are composed of intention trees (which

are derived, by a process of expansion, from classes), commercial automata (which encode business rules), and global constraints. Basically, an intention is a formal description of an e-commerce activity, such as a sale, in which a party operating party machine is willing to engage.

The plurality of components of the party machine include a Negotiation Control Program (NCP), which is an overall coordinator of the activities of party machine. A Constraints Solver is controlled by NCP, but may optionally be queried by other parts of the party machine, and is used to check sets of constraints which are initially specified and/or generated during the unification process, as described in greater detail in Sections 4 and 5 below. Constraint solving is a process which is well known in the art (see for example [4, 5] for a description of constraint-solving techniques).

Briefly, the Constraints Solver returns an answer to the NCP, which may be either Unsatisfiable, such that it is impossible to find an assignment to the variables which appear in the constraints such that the constraints are satisfied, or Satisfiable, such that there exists a satisfying assignment. If the Constraints Solver returns Satisfiable, the Constraints Solver may optionally return a modified, and preferably simplified, constraints set.

An Automata Execution Engine (AEE), controlled by the NCP, is responsible for conducting negotiations and the business rules enforcement. This is done by executing commerce automata (CA), as described in greater detail in Section 3 below. When the execution ends, the AEE controlling the CA returns

either SUCCESS, i.e., the CA reached a final state, or FAILURE, i.e., the CA did not reach a final state. If the AEE returns SUCCESS, the NCP in control of the overall process (say NCP1) may optionally modify the EContract with the output of the CA. In this description, the AEE is optionally run by NCP1, preferably in case the CA is associated with a variable in the intention of NCP1's party, or optionally it is run by NCP2 (the NCP of the 'other' party), preferably in case the CA is associated with a variable in the intention of NCP2's party.

A Unifier is again controlled by the NCP and supervises the unification process, as described in greater detail below with regard to Section 4. Briefly, the unification process involves the unification of at least two, but optionally more, intentions submitted by the NCP of a party A and the corresponding NCP of a party B. If it succeeds, the Unifier returns the EContracts. The Unifier may optionally occasionally request the NCP to pass a set of constraints to the constraint solver or to pass a CA to an AEE (again, belonging to either party) for execution.

The principles and operation of a system and method according to the present invention may be better understood with reference to the drawings and the accompanying description, as well as to the examples below, it being understood that these drawings and examples are given for illustrative purposes only and are not meant to be limiting.

Section 2: Basics of the EContracts framework

The parties involved in an e-commerce activity must agree on a common vocabulary. The "words" of this vocabulary are called classes and, formally, they are *rooted labeled ordered* trees. The root of a class is labeled with the *class name*; the edges of the class are labeled with strings which hint at the function of the vertices; the leaves of the classes are labeled with typed variables.

Examples of classes are presented in Figures 1A-1D as trees, in which each leaf vertex contains a variable of a particular type (see below for an explanation of the different preferred types of variables). The type in *italic* script precedes the label for the name of the variable. For example, the Purchase contract class (Figure 1A) describes a commercial purchase transaction involving a buyer, a seller, a list of purchased vehicles and a payment. The Payment class (Figure 1B) describes a payment as being composed of an amount of payment and a method for performing the payment. The EC Authority class (Figure 1C) describes an authority, including identification information, address and name. The Car class (Figure 1D) describes a vehicle, including model, identification information, class information, and price. Each of these constituents of the classes is described with a typed variable.

The presence of variables in a class enables the class to be customized. There are preferably four types of variables. A first type of variable is an atomic variable. The names of atomic variables begin with a "$" and the values that can be assigned to these variables are values such as string, real and integer. Examples

of atomic variables in Figures 1A-1D include the identification string $id in Figure 1C, and the string $amount in Figure 1B, and so forth.

A second type of variable is a class variable. The names of class variables begin with an ampersand "&" and the values that can be assigned to these variables are class instances. Examples of class variables in Figures 1A-1D include the payment variable &payment and the EC authority variables &customer and &company in Figure 1A.

A third type of variable is an atomic list variable. The names of atomic list variables begin with a percentage symbol, "%", and the values that can be assigned to these variables are lists of atomic values.

The fourth type of variable is a class list variable. The names of class list variables are enclosed between parentheses and the values that can be assigned to these variables are lists of class instances. Examples of class list variables in Figures 1A-1D include the variable (vehicles) in Figure 1A.

These notions are captured in the following definitions. The atomic types are defined to be string, integer and real. Other types like date, boolean or enumerated types are possible, but the present description is limited to string, integer and real only for the sake of simplicity and without any intention of being limiting. There is also a set of class names which is a set of strings.

The following definitions are given solely for the purposes of explanation and without any intention of being limiting.

Definition 2.1 A *value* is either a string, an integer, a real, a class name or one of the special symbols N (for null), L (for lists) or CO for list containment constraints (L and CO are relationship designators, such that the corresponding list elements appear as children).

Definition 2.2 A *variable* is a triple (t,n,v) where t is an atomic type or a class name, n is a string and v is a value, such that n is the name of the variable. A triple (t,n,v) must satisfy the naming constraints defined above (e.g., atomic variable names must begin with a $ character), together with the obvious type-correctness constraint between t, n and v (i.e., a value must correspond to the type of the variable). A variable (t,n,v) is unbound if $v = \mathrm{N}$. A set of variables V is *proper* if every variable name in a triple of V is unique, i.e., appears in no other triple as the name entry.

The following definitions concern the words of the common vocabulary, namely the *classes*.

Definition 2.3 A *class*, over a proper set of unbound variables VAR, is a rooted labeled ordered (RLO) tree, denoted $(V,E,r,t,<_e, elf, vlf)$, where V is a set of vertices; E is a set of edges, $E \subseteq V \times V$; $r \in V$ is the root of the tree; t, the label of the root, is a class name; $<_e$ is a partial order relation over E that defines the relative order of the edges that emanate from the same vertex; $elf : E \rightarrow STRINGS$ is the *edge labeling* function (defined so that the labels of the edges that emanate

from the same vertex are all distinct); and let $V' \subseteq V$ be the leaves of T. *vlf*: $V' \rightarrow$ *VAR* is the (total and onto) *leaf labeling* function.

In Figure 1, each variable *(t, n, N)* was represented by *t*: n.

Definition 2.4 Let L be a finite set of class names. A *class hierarchy* H *over* L is a directed labeled rooted tree in which every vertex is labeled with a class name in L. No class name may appear twice in the tree.

Classes are organized in *class hierarchies*, each defining a specialization hierarchy. For example, the Car class of Figure 1D is a specialization of the Vehicle class. As a consequence, Car class instances can appear in the list of vehicles of a Purchase contract class instance, although such a relationship between classes does not presuppose any structural similarity between them.

An *ontology* is a set of hierarchies containing classes that are semantically related.

Definition 2.5 Let $L_1, \ldots, L_n$ be pairwise disjoint sets of class names. An *ontology* over $L_1, \ldots, L_n$ is a set of class hierarchies $H_1, \ldots, H_n$ over $L_1, \ldots, L_n$, respectively. An *ontology* groups classes which are semantically related, and thereby contains the class hierarchy specification for its classes.

A class named a is *contained* in an ontology O if a is a vertex label in a class hierarchy in O. A class named b is a *child* of a class named a in O if (1) there exists a class hierarchy T in O such that T contains two vertices u and v which are

labeled with *a* and *b*, respectively, and (2) there is an edge from *u* to *v*. Let the *descendant* relation be the reflexive and transitive closure of the child relation.

Without being limiting, the existence of three *basic* ontologies is assumed. The *contracts* ontology contains the possible e-commerce contracts, such as Purchase, Rent for example. The *items* ontology contains goods and services such as car, hair-cut for example, which can be the subject of an e-commerce activity. The *general* ontology contains e-commerce general concepts such as e-commerce authority, payment, interest rate, for example.

For each class name *t* defined in the basic ontologies, a *canonical class representation* for *t*, denoted C_t, is assumed to exist, which is a class whose root is labeled with *t*. An *instance of type t* is a class that is isomorphic to C_t, i.e., identical up to a consistent renaming of variables.

A *party* is an active component that may be involved in e-commerce activities, for example at an e-commerce WWW site, through commerce activities on the Internet or as a customer buying agent. The EContracts framework assumes a preferably symmetric model, such that the structure of all parties involved in an e-commerce activity is preferably identical, although alternatively differently structured parties may be accommodated in a negotiation. A party manages the *party information*, i.e., a standard relational database, or optionally a collection of files, that contains the party's global data, e.g., the party's identity, item lists, pricing information and so forth.

Section 3: Intentions

In addition to the party information, in order to advertise its business intentions as well to be machine analyzable, a party should include a formal specification of the way it operates, i.e., the skeleton of contracts it may enter as well as the business rules and the constraints it enforces. The EContracts framework represents this information in *intentions*. Whereas classes are the words of the common language, *intentions* are the sentences of this language. Sentences are built by connecting words, such that an intention is composed of an *intention tree* which is derived from classes, *commerce automata* which encode business rules, and *constraints*.

Intention trees describe the structure of EContracts a party is willing to establish. Intention trees are derived from e-commerce contract classes and are transformed into actual contracts by *instantiating* variables, in order to define the party's requirements, and by adding *operator vertices* that enable the specification of powerful logical constraints.

For example, in Figure 7, the customer, J. Smith, wishes to purchase two motorcycles or, alternatively, an Economy-class car. He is ready to pay by either cash or check. In Figure 8, the PurchaseOnline Corp. is selling cars (one at a time) and is only accepting cash.

Note that the two intention trees in Figures 7 and 8 are complementary. The purpose of unification is to detect this fact and to build a unified tree from the intentions, namely the EContract, which is shown in its final form in Figure 9.

These Figures are explained in greater detail below.

Variable instantiation. Formally, variables are instantiated by using the α operator. The α operator takes a tree and a variable-instantiation operation, and produces a tree as follows. Let T be an intention tree and let $x = (t, n, N)$ be an unbound variable appearing in T.

If x is an atomic variable, and v is a value of type t, $\alpha\ (T, x = v)$ *is defined to be* T' where T' is presented in Figure 2A. In the figure, "boxed T" symbols represent (sub-)trees and "boxed x" symbols represent vertices.

If x is a class variable, let t' be a class name which is a descendant of t in an ontology and let O'_2 be an instance of type t'. $\alpha\ (T, x = O'_2)$ *is defined to be* T' where T' is presented in Figure 2B.

If x is a class list variable, let $(t'_1, \ldots, t'_n)$ be a sequence of class names which are descendants of t in an ontology and let $(O'_1, \ldots, O'_n)$ be instances of types $(t'_1, \ldots, t'_n)$, respectively. $\alpha\ (T, x = (O'_1, \ldots, O'_n))$ *is defined to be* T', where T' is presented in Figure 2C. Instantiation of atomic list variables is defined similarly.

Similarly, if x is a class list variable, let $(t'_1, \ldots, t'_n)$ be a sequence of class names which are descendants of t in an ontology and let $(O'_1, \ldots, O'_n)$ be instances of types $(t'_1, \ldots, t'_n)$, respectively. Now $\alpha\ (T, x \supseteq (O'_1, \ldots, O'_n))$ *is defined to be* T', where T' is presented in Figure 2D. The meaning is that the list

that can be assigned to x must contain at least $(O'_1, ..., O'_n)$, that is x must satisfy a *list containment constraint*. This operation is a partial assignment, as it constrains the possible values of x. List containment constraints on atomic list variables are defined similarly. A list containment constraint of the form $x \subseteq (O'_1, ..., O'_n)$ can be specified using OR vertices which are defined below.

Operator vertices. Operator vertices are vertices labeled with the strings AND, OR and NOT. Operator vertices are added to an intention tree by using the Δ operator. Let T be an intention tree. T' is *derived* by adding to T an operator vertex o as follows.

If o is an OR vertex or an AND vertex, then let u be a vertex in T, let (u,v) be an edge labeled with *lab*, and let V be the subtree rooted in v. Let V_1, V_2 be trees isomorphic to V up to renaming of variables. $\Delta(T, u, o, V_1, V_2))$ is defined to be T', where T' is obtained from O by (1) removing V from O, (2) adding an edge (u,o) labeled *lab*, and (3) adding edges from o to the roots of V_1 and V_2 (see Figure 3A).

If o is a NOT vertex, then let V_1 and V_2 be the two subtrees rooted at an AND vertex, such that their roots are not already NOT vertices. o can be added to the intention tree as the root of one of V_1, V_2, as described in Figure 3B (for V_2).

Figure 4 presents an example of the use of operator vertices. Recall that CO is a list containment constraint, e.g., variable (x), when instantiated, should contain at least O_1 and O_2. The meaning is that the list of items (of type t) must contain at least O_1 and O_2, or O_4 and O_5, but must not contain O_3.

In an intention, the (sub-)trees rooted at vertices that are labeled with the same variable name are required to be identical.

The α and Δ operators may be applied to any class instance leading to the construction of a *derived instance*. For example, the subtree rooted at the Customer edge in Figure 7 is a derived instance of class *EC Authority*.

Constraints An intention contains a set of *constraints*. A *constraint* is a function from a value assignment (to a set of variables) to the boolean values TRUE and FALSE. The sub-language used for the expression of constraints is not part of the EContracts framework specification. For the sake of simplicity, in examples, a simple constraints sub-language is used, which is called *SIMPLE-C* and which is presented through examples. For example, not(Ground($title)) AND ($price > 100) AND ($name = "John") AND (($name, $price) ∈ R) is a constraint. Note that Ground means "is not null" and R denotes a set (relation) of tuples. The assignment C={$title → *null*, $price → 150, $name → "John", R → {("John",150), ("Steve",170)}} *satisfies* the constraint.

Commerce automata (CA) Negotiations upon variable values (e.g., $price) and business rules enforcement can be expressed by assigning *commerce automata* to atomic variables, class variables and list variables that appear in intention trees. For the sake of simplicity only and without any intention of being limiting, this description does not consider automata for list variables. They are an

extension of the automata for class variables. Furthermore, only business rules and negotiations involving two parties are considered, again for the sake of simplicity only and without any intention of being limiting. However, it is possible to define negotiation protocols involving more than two parties.

Variables. Consider a CA A which is assigned to a variable x of type t in an intention tree. If x is an atomic variable, *executing* A leads to the assignment of an atomic value of type t to x. In this case, the set of A's *output variables* is $\{x\}$. If x is a class variable, A specifies at least an *output instance* O which is a derived instance of type t' where t' is a descendant of t in an ontology. Let $x_1, ..., x_n$ be the atomic variables that appear in O. Executing A assigns atomic values to some of the variables among $x_1, ..., x_n$ and assigns the resulting instance to x. In this case, the set of A's output variables is $\{x_1, ..., x_n\}$.

To build the assignment to the output variables, A uses a set of *internal variables* which can be atomic variables or relation variables, i.e., variables that can be assigned entire relations.

An automaton is provided with an initial assignment to its variables (determined by unification, as shown by the example in Section 4) and the assignment may be modified during its execution. The atomic variables are typed and the relation variables have an associated arity (i.e., the number of columns in the corresponding table). Column names may correspond to variables in the output instance of A.

Parties and messages. The execution of a CA is defined relative to two parties that exchange *messages*. The roles of the parties during the execution are asymmetric. The *active* party of *this* interaction, the one whose automaton initiated the message exchange, sends *inquiry messages* to the *passive* party, and the latter replies with *answer messages*. It is understood that the parties may alternate roles through different interactions, such that a passive party for this interaction may become the active party for the next interaction, and so forth.

The possible inquiry messages and the corresponding answer messages are as follows.

Send t. The active party requests an assignment for the variable t, where t is a variable of any type. The passive party must reply with t = v, in which v is a value of the same type as the variable t; or with a *choose* message which is defined below.

Confirm t=v. The active party requests a confirmation regarding the assignment of value *v* to t from the passive party. The passive party must reply with Yes to confirm; No, to disallow; *confirm t = v'*, in which v' is a counter offer for the value to be assigned to t; or a *choose* message, as defined below.

t = Choose C from R format F. The active party proposes to the passive party a set of alternatives from which a choice for the value to be assigned to the variable t should be made. The number of alternatives to be selected depends upon the value of the constraint *C*. In this message, t is the variable, and the

constraint *C* combines terms of the form m=*n*, *m*>*n*, *m*<*n*, *m*<=*n or m*>=*n*, in which *m* is a natural number, for example *1*<=*n*<*3*. *F* is an array describing the names and types of the columns of *R*. The format of this array is *Col[i].Name = Name of column i in R* and *Col[i].Type = Type of the value in column i in R*. The passive party must reply with an agreement to one or more alternative choices which are selected from *R* conforming with C; or *t = Choose C' from R' format F'*, which constitutes a counter offer.

The names of variables and of columns of relations in messages constitute a vocabulary which must be mutually understood by the parties. These names are understood in the context of the initial unification between the output instance of the activated automaton, say associated with party A, and either (1) a subtree of party B's intention, or (2) the output instance of a party B automaton. Whichever the case may be, this initial unification establishes an initial vocabulary of variable names and edge labels which may be used in messages to clarify the meaning of later variable and column names.

Similarly, the values which are transmitted in messages, including values which appear inside tables or lists, may optionally be specified to be either hard values which are not negotiable, or soft values, which are negotiable. Soft values may be so indicated by a marker such as a question mark, for example. For example, if the active party sends the message "confirm price=5?", the other party may answer with a counter offer, since "5?" is a soft value. On the other hand, if the message is "confirm price=5", the price is not negotiable and there is no point

in sending a counter offer. A similar mechanism may apply when sending values in a table or list from which a selection should be made.

The replies to these messages are optionally determined by the passive party according to a plurality of preferences. These preferences may optionally and preferably include default options, relative preferences, negotiation strategies for particular items, mechanisms for performing parallel negotiations, and software modules for conducting negotiations according to specific principles.

For example, with regard to default options, when asked to make a choice, the passive party could respond by always choosing the first choice or the last choice, or a random choice, or may require the human operator to be queried concerning the choice. Relative preferences can be determined by ranking constraints, for example. Optionally, intention tree nodes can be ranked as guidance for best-effort performance of the unification algorithm (see Section 4 below).

A negotiation strategy for particular items may involve determining acceptable prices or delivery dates, for example. The strategy optionally includes a "bottom line" offer and modes of reacting to counter offers, preferably including a "rate of convergence" to the bottom line offer. Such strategies may also optionally include mechanisms for performing parallel negotiations, for example in order to determine how negotiations with one party should affect negotiations with other parties.

Optionally, software modules which are dedicated to conducting

negotiations based on set principles may also be included within the party architecture of Figure 11, as described with regard to Section 5, in order to determine the answers to the messages of the active party. Examples of such set principles include, but are not limited to, AI (artificial intelligence), neural networks, psychological principles, economics or any other set of principles.

Optionally and more preferably, the preferences of each party are specified textually and/or through a GUI (graphical user interface). Optionally and also more preferably, these preferences are specified at several levels. For example, these preferences may concern specific features in a deal. Typical examples are *lowest price* or *earliest delivery date*. As another example, these preferences may concern a particular set of features in a deal. For example, a preference may link the price with the quality of the products, as in *accept lower quality in conjunction with a better price*. As yet another example, preferences may be specified for the deal as a whole, such as a preference for deals with no extra options, or, an insistence for deals in which all the dates must be fully specified. More specific preferences preferably are emphasized over less specific, more general preferences.

These user preferences are then preferably compiled, or translated into, automata, optionally and preferably with other business rules. Such a process of translation may optionally be automatic or manual. The previously described GUI may optionally also be used to embed business rules by presenting various options to a user, such as a buyer, seller or participant in a symmetric negotiation. Based

on the selected options, either manually or alternatively through a compiler, the preferences of the user are translated into automata which are associated with variables in an intention.

Negotiation Automata (NA). Furthermore, the compiled user preferences may optionally and preferably be used in a preferred embodiment of the present invention, which uses negotiation automata (NA). An NA is a computational device associated with every intention tree node, and not only leaf nodes such as in the case for commerce automata (CA). The NA which is associated with a node v answers messages regarding values and variables occurring in its sub-tree. Every intention tree node is conceptually associated with an NA. When such an NA is not able to answer a message, that NA passes the message to the NA associated with its parent node. The uppermost NA, associated with the root node, answers with default values if necessary, which may optionally be those values determined according to compiled user preferences for example. This case is similar to the one in which the NCP answers all the messages. The exact internal structure of the NA may optionally be unspecified. Optionally the NA may resemble a CA, and alternatively it may be a program implemented via any language on any computer. The implementation may also optionally include manual answers.

The NA's are useful for a number of purposes. For example, a buyer may indicate an interest in products which have delayed expiration dates, and in addition, for each expiration date interval, specify a maximum acceptable price. In the intention of the buyer, the list of products to buy is represented by a variable

such as a. The preferences of the buyer are preferably compiled into an NA associated with a, the purpose of which is to answer propositions and to negotiate with regard to expiration dates and prices.

Optionally, a party may use one of its own CA's in order to generate some part of its intention tree and then, one of its own NA's in order to check whether the generated part complies with its preferences.

The relational store. During its execution, a CA can query the relations in its *relational store* which contains (1) the relations in the active party's party information and (2) relations for relation variables. Furthermore, a CA can access the labels of vertices of intention trees. For example, the value of the Number leaf in the intention tree in Figure 7 is given by *Purchase.Parties.Customer.Address.Number*.

Also optionally and more preferably, accesses to databases are specified according to some version of SQL (Structured Query Language), which is a standard database language.

States. A CA has a set of *states* S. One state is distinguished as the *starting state* and there exists a non-empty subset $S_f \subseteq S$ of *final states*. Each state is labeled with an *assignment program*, i.e., a sequence of assignment statements. Given an assignment to the automaton variables, say σ, the *execution* of an assignment program P modifies σ by executing the assignment statements, one

after the other. The assignment statements and their semantics are presented in the example of Table 1.

The CA *transition function*, say δ, is applied to a state and a constraint and yields a state. For example, $\delta(s_1, \text{ground}(\$x)) = s_2$, means that if the CA is in state s_1 and the variable $x is ground (in the state of the current assignment) then the CA should move to state s_2.

Definition 3.1 (Commerce Automaton) A *commerce automaton*, say A, is a tuple $A = (S, b, S_f, O, V, P, f_P, \delta)$ in which the following definitions apply. S is a set of states. $b \in S$ is the starting state. $S_f \subseteq S$ is the set of final states. O is the output specification. V is the set of the automaton variables. P is a set of assignment programs and f_p is a function that maps states in S to programs in P. δ is the (partial) transition function $\delta: S X SC \rightarrow S$, where SC is the set of all SIMPLE-C constraints. O may be an instance of a class t or optionally obtained from such an instance using a sequence of variable instantiations.

As part of a CA execution, messages are sent and answers are received. In this formalization, the sequence of received messages is modeled as a stack of messages. In reality, answers are generated by the passive party based on its perceived state and negotiation strategy. Given an initial assignment δ and a stack of answer messages Γ, the *execution* of the automaton is defined as follows. The execution begins at the starting state with the initial assignment. When the

automaton enters a state s, it modifies δ by executing the program $f_p(s)$. If $f_p(s)$ involves message exchanges, the answer to each inquiry message is popped from Γ. If Γ is empty or the answer message in Γ does not correspond to the inquiry message, then the execution stops. The constraints on the transitions from s are checked. If none is TRUE, or more than one is TRUE, then the execution stops. If exactly one is true, the automaton moves to the new state. If no transition exits from s, the execution stops in s. If the execution stops in a final state, then the execution is *successful*, and otherwise it *fails*.

Consider the CA APrice in Figure 5A which is assigned to the atomic variable Sprice in the used car dealer's intention (Figure 8). The company uses this automaton in order to assign a value to Sprice. The starting state is 1. First, the price of the purchased vehicle is assigned to Sprice (with a discount applied) and, using the Confirm construct, the company asks the customer for price confirmation. The customer's answer is assigned to the variable Sconf. If it is Yes, the automaton's execution is successful (state 2), otherwise it fails. It fails in state 1 (if the answer is neither Yes nor No) or in state 3 (if the answer is No).

With regard to the CA in Figure 5B, the convention is that an order condition involving a variable which is not ground evaluates to FALSE. This automaton is assigned to a class variable, say x, and, therefore, it defines an *output instance* (shown in Figure 5C) that should be assigned to x, in case the execution of the automaton succeeds. The automaton is provided with an initial assignment of its variables. If the initial assignment is $\{\$b \rightarrow 1\}$, the automaton enters state 2

and stops. Since 2 is not a final state, the execution fails. If the initial assignment is {Sb → 1, Sc → 1} the two constraints are satisfied, therefore the automaton cannot move to the next state, and, therefore, stops (and fails) in state 1. If the initial assignment is {Sc → 1} the automaton enters state 3 and the execution is successful; 2 and 5 are assigned to Sa and Sb, respectively, in the output instance.

An intention and a party data structure can now be formally defined as follows. An *intention* is a tuple (T,F,S,C) where T is an intention tree, S is a set of CA's, F is a partial function from the atomic variables and the class variables that appear in T to S, and C is a set of constraints. A party data structure is a tuple (SI,I) where SI is the party information and I is a set of intentions indicating the EContracts the party is ready to enter.

Less formally, intention trees describe the structure of Econtracts (electronic commerce contracts) that a party is willing to establish. Therefore, intention trees are derived from e-commerce contract classes. These contract classes are transformed into specialized contracts through the use of instantiating variables and introducing operators as previously described. If the intention trees of two parties are complementary, then the unification process detects such complementarity in order to build a unified tree from these intentions, which forms an EContract. Parts of this construction involve the instantiation of variables via automata, a process that optionally involves the exchange of messages between the parties and which therefore optionally includes a process of negotiating.

Section 4: Unifying two intentions

As previously described, the unification of the intention trees of two parties leads to the establishment of an EContract. Such unification is preferably performed through a process which is essentially a process of negotiation, and which can be either automated or semi-automated, as previously described. This Section provides a formal description of the process of unification, along with examples of preferred unification algorithms.

Basic unification The unification algorithm is an extension of the unification algorithm for terms in logic and in logic programming. The algorithm is extended to handle operator vertices and CA's and is presented through the following example (the algorithm is formally described in the Appendix). The customer (whose intention tree is shown in Figure 7) has one constraint, i.e., that the cost is less than $300 ($price < 300). The used car dealer (whose intention tree is shown in Figure 8) has two CA's. The Acar CA, which is associated with the variable &Car in the intention tree, describes how cars are sold (Figure 6 contains a part of the automaton definition). The second CA, APrice (shown in Figure 5A), is associated with the variable $price. PurchaseOnline's site information includes the relation Rcar(Model. ID, Class, ListPrice).

The unification starts at the roots of the two intention trees. In the Parties subtree, the Customer and UsedVehicleDealer edges are unified. Corresponding subtrees are assigned to the variables &customer and &company, respectively. At

the Vehicles subtree, the algorithm reaches an OR vertex in the customer's intention tree. In turn, each subtree under the OR vertex is unified with the Vehicle subtree in the company's intention tree. The unification of the left branch obviously fails, since, it is impossible to unify a list of two motorcycles with a list that contains one car. At the right branch under the OR vertex of the customer's intention tree, the vertex labeled Car is unified with the vertex labeled &Car in the company's intention tree. Since the variable &Car is assigned to the Acar CA (shown in Figure 6B), the customer's subtree rooted in Car is unified with the output instance of the Acar CA (shown in Figure 6A). This unification provides the *initial* assignment for the CA variables, i.e., Economy is assigned to $class.

The Acar CA is executed as follows. Since the variable $class is ground, the automaton moves to state 1. The automaton assigns to the relation variable *A* all the cars that correspond to the customer's class specification (Economy). Then, the automaton asks the customer (party) to choose a model. This choice may be done in several ways; human intervention may be requested, or an automatic tool, for example, an NA as defined above may be used. Such an automatic "expert" tool may, simply, choose an arbitrary car or employ more complex user defined strategies. It can also try every choice, one after the other, and use backtracking if some choice leads to the failure of the automaton (The term "backtracking" indicates repeated trials by returning to earlier choices and considering alternatives to these previous choices, and is a technique which is known in the art. For example, this technique is employed in the Prolog language and interpreter as well

in certain AI (artificial intelligence) systems.).

After receiving the model name, say "Cavalier", the automaton selects the car, say (Cavalier, 322, Economy, 230), from the database (state 2). When the automaton reaches its final state (state 2) the assignments are $model←"Cavalier", $id←322, $class←Economy, $price1←230. These assignments are applied to the output instance of the automaton. The (modified) output instance replaces the node labeled &Car in the intention tree of the used car dealer (Figure 8) and the subtree rooted at the "boxed" Car node in the customer's intention tree (Figure 7).

Following this assignment, the current constraint set ({$ListPrice = 230, $price < 300}) is verified as satisfiable and the unification algorithm resumes. Optionally, the automaton state is kept in order to be able to backtrack to this state later in the process of negotiations, in case of a failure of a later state, for example if backtracking is required in order to perform unification by returning to a previous state.

The unification proceeds to the Amount-edge and the APrice CA (shown in Figure 5A) is executed. After confirmation, the new set of constraints {$ListPrice = 230, $price = 204.7, $price < 300} is checked by the constraint solver and the unification proceeds to treat the Payment subtree. The generated EContract is depicted in Figure 9.

With regard to backtracking, each CA or NA is preferably implemented as a stand-alone independent process with the following characteristics, explained

with regard to the Prolog language, although it is understood that such a process could be implemented in other programming languages such as C++ or Java, for example. First, the three intention trees, from the first and second parties, and the partially unified tree, are preferably passed between the parties as the process of unification proceeds. This convention enables backtracking to be more easily performed, by providing access to the values of the trees at each stage.

Second, a message is preferably sent by the *Send* predicate and a message is preferably received by a *Receive* predicate, which are implemented as Prolog commands.

Third, the Prolog language provides for automatic backtracking for a *Send* or *Receive* command, without any side effects, to the predicate or rule immediately proceeding the execution of the command. An automaton statement which sends a message and assigns the result to a variable is implemented through a *Send* predicate followed by a *Receive* predicate.

Fourth, a message can be sent from a CA to the appropriate NA. The appropriate NA can be determined from the original unification performed when the automaton execution was requested. Observe also that a CA can optionally invoke the services of an NA of its very own party, say for consultations.

Fifth, when an NA cannot answer a message, it passes the control to the closest ancestor automaton in the intention tree, by calling the Prolog program implementing the automaton. A CA or an NA can optionally navigate through the

intention trees and refer to each node according to the fixed or relative path from the current position. This enables the CA or the NA to refer to values of various variables within its code.

For an implementation with SQL as the access language to the data in relations, the backtracking of SQL commands within a CA or an NA is preferably performed as follows. An assignment out of a "select" command simply moves to the next tuple, which is similar to the traditional SQL cursor mechanism. When no further tuples are available, the "next" tuple is assigned a null value, such that retrieving this tuple results in a failure. An insert or delete statement is backtracked by moving to a savepoint immediately prior to the insertion or deletion, respectively.

A Best Effort Unification Algorithm This algorithm is an illustrative example of a preferred algorithm for use in situations where the unification algorithm fails. This preferred algorithm is an approximate unification algorithm. The basic underlying idea is that of *upgrading* parts of intention trees. As an example, suppose that an intention tree specifies the constant *red* in a node. Suppose further that this is in fact a preference rather than an ultimate requirement. One option is to use OR nodes and give additional color options (observe, that by the way the Prolog interpreter operates, priorities of colors are naturally assigned in left to right order). But, the specification of many colors is tedious, such that in addition, preferably the party may even allow *any* color as a

last resort. The proposed solution is to *prioritize* at least some of the nodes and edges of the intention tree. A priority is a natural number, such that the higher the number, the more important is the constraint represented by the node. Similarly, constraints in the set of constraints associated with the intention may also optionally be priontized.

If priorities are assigned to edges connected to the alternatives of an OR node, AND node, or to list elements, then the highest priority alternatives within such OR, AND or list node are tried first. The others may be considered to be temporarily eliminated. So, these priorities indicate an order for the unification algorithm. (This is not coded in the algorithm presented in the Appendix.)

Priorities in nodes and edges can be used as follows. Suppose unification fails, then a low priority node can be replaced with a less constraining node. This replacement is optionally performed by "upgrading" the node. A *node upgrade* can be any sequence of *actions* (as defined below) applied to nodes in the intention which result in an acceptable tree. Some actions apply to edges and make them less constraining. An *action* is defined as one of the following.

First, consider a node labeled with a variable of class c, the variable is modified to be of class c' which is a superclass of class c. The modification applies to all occurrences of the variable.

Second, consider a node labeled with a variable X. The node is relabeled with a variable Y. If variable Y appears elsewhere in the intention, the node must be labeled with the same class as in other occurrences. Variable Y may also chosen

as a completely new variable.

Third, consider a node which is the root of a subtree and labeled by a (bound) variable. Make the variable unbound by erasing the subtree, except for the node that is now labeled with the unbound variable. The modification applies to all occurrences of the variable.

Fourth, consider a list node connected via edges to the list elements. Eliminate a list element.

Fifth, consider a node labeled with a variable X which is associated with an automaton. Disassociate the variable from the automaton.

Sixth, consider an edge e with label *lab*. Change *lab* to another label that appears in one of the intentions or eliminate the label altogether.

Seventh, consider a node in the tree, connected via an edge e to its parent, which is the root of a subtree T. Eliminate edge e and the subtree T altogether. This is a drastic measure that may be needed if, for example, multiple versions of classes exist due to outdated or erroneous software. It is also possible that portions of trees are stored in various media or locations that may be inaccessible, temporarily or permanently.

So, upgrading provides further options to the unification algorithm to explore. It may result in solutions that only approximate true unification of the pre-upgraded intentions, thereby "unifying as much as possible".

There are some technical issues to consider. One such issue is that the upgrading of the least important node may not suffice to produce a unified

intention. Further upgrades may be required, but then the question arises of the order in which to perform them. Suppose that 4 nodes A,B,C and D are labeled with decreasing priorities, say 4,3,2 and 1, respectively. An order that seems most reasonable is as follows (other orders are also possible): first, upgrade D; if the above action fails upgrade C; if the above action fails, upgrade C and D; if the above action fails, upgrade B; if the above action fails, upgrade B and D; if the above action fails, upgrade B and D and C; if the above action fails, upgrade A; if the above action fails, upgrade A and D; if the above action fails, upgrade A and D and C; and if the above action fails, upgrade A and D and C and B.

It should be noted that an aggregate condition may optionally be demanded in defining the best approximation, e.g., as a function of priorities as well as the number of upgrades. Also observe that if a prioritized node u is the parent of another node v, once u is labeled with an unbound variable there is no need to try upgrades to node v, the node is no longer in the tree.

Another issue is determining the order for applying upgrades if two intentions are given. A reasonable but optional mechanism is to alternate between the two intentions, for example by mapping the priorities of the first intention to odd numbers and those of the second intention to even numbers, and then applying the upgrades to the intentions in priority order as described above. Other prioritizing schemes are also possible and are considered to fall within the scope of the present invention.

Constraints may optionally and preferably be relaxed in a similar way,

optionally with more degrees of relaxation. For example, $a < b$ may be relaxed to $a \leq b$. Relaxation may also optionally eliminate a constraint altogether. Here again, the priority of the constraint indicates its importance and order of relaxation or elimination.

Section 5. Examples of Preferred Implementations

The previous Sections considered a formal description of one implementation of the system and method of the present invention. This Section describes preferred embodiments of the present invention, which are specific examples of different applications of the present invention. These examples are intended only to illustrate the present invention, and should not be construed as being limiting in any way.

As shown in Figure 10, a system **100** has a central server **102**, a first party **104** and a second party **106**. Each of first party **104** and second party **106** operates a party software module **108**, which is optionally the software of Figure 12, as described in greater detail below. Central server **102** is used to locate relevant parties for intentions, for example through registration, searching, or a combination thereof. Once first party **104** and second party **106** have been located, the respective party software modules **108** conduct the negotiations.

For example, suppose first party **104** is a buyer who wishes to purchase 4 of product A and 4 of product B. Central server **102** identifies second party **106** who supplies product A, third party **110** who supplies product B and fourth party **112**

who supplies both product A and product B. Negotiation is preferably performed in parallel between first party **104** and each of second party **106**, third party **110** and fourth party **112**. First party **104** may therefore optionally be required to present portions of its intention as separate intentions to each of second party **106**, third party **110** and fourth party **112**. The optional separation of intentions is performed by party software module **108**. First party **104** may then optionally choose to purchase one of product A from second party **106**, one of product B from third party **110** and three each of products A and B from fourth party **112**. For this embodiment, central server **102** is optionally replaced by any Internet search engine, such as "Google" for example [*http://www.google.com* as of January 2, 2000].

In a second illustrative embodiment, each buyer is equipped with basic software for determining intentions, automata and preferences for negotiation. Each seller is equipped with similar software, as well as with connections to corporate data. Buyers and sellers, who may be one of the parties **104**, **106**, **110** or **112** of Figure 11 for example, register with central server **102**. However, now party software modules **108** of each party are preferably restricted in function, such that central server **102** performs the process of negotiation, as a trustee of the parties. Therefore, party software modules **108** could even optionally be implemented through a Web browser, for example, optionally with applets or Java scripts, or other scripts, or even with a specially built "thin" Web browser which is dedicated for this purpose.

Central server 102 may optionally store intentions, or alternatively may use intentions stored at each party. Central server 102 may also optionally offer additional services such as financial services, advertisements, supplier ratings, customer ratings, and product and service reviews.

In an optional variation of this embodiment, central server 102 executes negotiations on behalf of at least one but not all parties, while at least one party executes its own software at its own site. In this variation, also optionally, a client or party may participate without a computer and software, by submitting intentions manually to central server 102, for example.

In a third illustrative embodiment, central server 102 itself may be a party to commercial arrangements. For example, central server 102 may optionally purchase three of product A from second party 106, one of product B from third party 110 and three each of products A and B from fourth party 112. At end of the negotiating process, central server 102 remains holding two units of product A, which central server 102 can then sell to another party. This provides the possibility of brokering a plurality of commercial arrangements in "back to back" deals, packaging by combining the intentions of various buyers to obtain a larger volume, and so forth. Thus, in this embodiment, central server 102 is a broker.

Any of these embodiments may optionally be operated by vendors who are oriented to a particular market segment, such as travel or consumer electronics for example, by a company and its suppliers and/or customers, by a group of companies or organizations, within a particular company, or by individuals

wishing to construct a marketplace.

Referring now to the drawings, Figure 10 is a schematic block diagram of an e-commerce party according to the present invention. The EContract framework defines the basic software components of an e-commerce party and their interconnections. As shown, a party machine **10** features a plurality of parts, with associated data structures **12**, including a party information data structure **14** and an intentions data structure **16**. This complete embodiment of party machine **10** should be installed at each party of Figure 11 for the first embodiment, in which the parties negotiate between themselves, such that party machine **10** acts as a device for negotiations within the context of the system of Figure 10. Alternatively, for the second embodiment, in which the server acts as a trustee for the negotiations, each party need only have intentions data structures **12**.

Party information data structure **14** is preferably constructed as a standard relational database, or optionally as a collection of files, containing the global data of party machine **10**, such as item lists, pricing information and so forth. This global data is described in greater detail above with regard to Section 2. Optionally, at least a portion of party information data structure **14** may be queried by other party machines **10**, although preferably, a least a portion of party information data structure **14** is opaque, or not accessible, to other party machines **10**. More preferably, party information data structure **14** includes data which defines the legal status of the party which operates party machine **10**, such as the name, address and telephone number, for example, of the party which operates

party machine **10**.

Intentions data structure **16** preferably defines the formal structure of the commerce intentions of party machine **10**, expressed as a plurality of intentions. These intentions are described in greater detail above with regard to Section 3. Intentions are composed of intention trees (which are derived, by a process of expansion, from classes), commercial automata (which encode business rules and global constraints). Basically, an intention is a formal description of an e-commerce activity, such as a sale, in which a party operating party machine **10** is willing to engage. Intentions data structure **16** is optionally and preferably implemented with XML (Extensible Markup Language).

Preferably, intentions data structure **16** is in the form of a tree, with a plurality of components. Optionally, intentions data structure **16** is also stored at the server of Figure 11, more preferably storing a separate intentions data structure **16** for each party, or client, of Figure 10.

The plurality of parts of party machine **10** include a Negotiation Control Program (NCP) **18**, which is an overall coordinator of the activities of party machine **10**. NCP **18** is preferably operated by the server for the second embodiment of Figure 10, in which the server acts as a trustee. More preferably, the server also operates all of the parts of party machine **10** which are controlled by NCP **18** for this embodiment. Also in this embodiment, NCP **18** is implemented as an instance (i.e., a "copy") of an NCP for the particular process of negotiations being handled by the server. The NCP also encompasses and controls

the negotiation automata (NA's) which are associated with intention trees nodes.

A Constraints Solver **20** is used by NCP **18**, or alternatively may be used by an AEE **22**, or even preferably by any automaton. Constraints Solver **20** is used to check sets of constraints which are initially specified and/or generated during the unification process, as described in greater detail in Section **4** above. Briefly, Constraints Solver **20** returns an answer to NCP **18**, which may be either Unsatisfiable, such that it is impossible to find an assignment to the variables which appear in the constraints such that the constraints are satisfied, or Satisfiable, such that there exists a satisfying assignment. If Constraints Solver **20** returns Satisfiable, Constraints Solver **20** may optionally return a modified, and preferably simplified, constraints set.

An Automata Execution Engine (AEE) **22**, controlled by NCP **18**, is responsible for the negotiations and the business rules enforcement. This is done by executing commerce automata (CA), as described in greater detail in Section 3 above. However, it should be noted that NCP **18** and AEE **22** may optionally not belong to the same party. For example, when unifying the intentions of Party A and Party B, NCP **18** of Party A may request from NCP **18** of Party B to forward a request of an automaton execution to AEE **22** of Party B. When the execution ends, AEE **22** of Party B returns either SUCCESS, i.e., the CA reached a final state, or FAILURE, i.e., the CA did not reach a final state. If AEE **22** returns SUCCESS, NCP **18** may optionally modify the EContract with the output of the executed CA.

Furthermore, AEE 22 may optionally continue to maintain a particular execution state, in case this execution state is requested later on, for example, for performing backtracking. Optionally and preferably, Constraints Solver 20 and AEE 22 are operated by each party, or client, for the second embodiment, and provide data to NCP 18 at the server which is acting as the trustee for the negotiations, in order to block access to certain information of the party, such as the constraints for example.

A Unifier 24 is again controlled by NCP 18 and supervises the unification process, as described in greater detail above with regard to Section 4. Unifier 24 is preferably operated by the server for the second embodiment of Figure 10, in which the server is the trustee for the negotiations. Briefly, the unification process involves the unification of at least two, but optionally more, intentions submitted by NCP 18 of a party A and the corresponding NCP of a party B. If it succeeds, Unifier 24 returns the EContracts. Unifier 24 may optionally occasionally request NCP 18 to pass a set of constraints to the constraint solver or to pass a CA to AEE 22 for execution. AEE 22 may optionally be AEE 22 of either Party A or Party B.

One example of a method for operating the system of Figure 11 is explained in greater detail below, with regard to the flowchart of Figure 12. The description of this method refers to "two parties", it being understood that these are two separate party machines 12, which could optionally be located at two separate clients, at a client and at the server, or alternatively both could be located at the server. In step 1, preferably the first party receives a copy of the intentions

data structure 16 of the second party. In step 2, NCP 18 of the first party compares at least a portion of intentions data structure 16 for the first party to intentions data structure 16 for the second party.

In step 3a, if a suitable match is found between the two portions, preferably they are merged to form a third merged intention data structure 16. Steps 2 and 3a are performed again at least once, and optionally and preferably are performed until the third intentions data structure 16 is complete, such that both the first and the second intentions data structures 16 have been merged.

Alternatively, in step 3b, if a suitable match is not found, but at least one portion is associated with an automaton, then AEE 22 controlling that automaton is executed. In step 4, optionally and preferably, the automaton sends a message to a corresponding negotiation automaton of the other party. If there is no corresponding negotiation automaton, then the message is sent to NCP 18 of the other party. The message may optionally include a suggested change in a value for one or more variables, and selecting from among a list of possible values for one or more variables.

In step 5, NCP 18 and/or corresponding negotiation automaton of the other party sends a reply, which may optionally confirm the suggestion, make a choice, or make a counter-offer, for example. Steps 4 and 5 are optionally repeated at least once. After this exchange of messages, the automaton ends execution either successfully or with failure, in step 6 (1). If execution ends with failure, preferably step 3c is now performed. If execution ends successfully, the generated

output instance replaces the variable that was previously associated with the automaton in step 6 (2). The method then optionally and preferably returns to step 2.

Also alternatively, in step 3c, if a suitable match is not found and there is no associated automaton, then preferably backtracking is requested by NCP 18, to return the third intentions data structure 16 to a previous state. If such a previous state is found, then the process continues from step 2. Otherwise, the process ends.

If all, or at least an acceptable fraction, of the portions of the first and the second intentions data structures 16 can be merged, then the negotiation process concludes as a success. Otherwise, it fails.

If unification fails, backtracking is optionally performed. Unifier 24 then preferably reviews previous actions and attempts to achieve unification by finding an alternative path to match the intentions of both parties, as described below in greater detail.

According to an alternative embodiment of the present invention, as described in the third example of Figure 10 above, both the server and each party may hold party machine 10 for conducting negotiations. Alternatively, the server may hold all components of party machine 10, with the optional exception of those parts described above, and may conduct negotiations with itself, both on behalf of another party and as a client.

According to a preferred embodiment of the present invention, an intention can be translated from a data structure such as a tree into natural human language of one or more parties. This is done by associating each class with a descriptive human language sentence with place-holders for the values of variables. These place-holders are then completed once the values for the variables have been determined during the process of negotiation. At the end of the process, the negotiated agreement can be so constructed in a natural human language, by reading out each sentence and filling in the determined values for the variables. The structure may optionally be nested, such that a place-holder may itself be filled with a class, which in turn has its own description and place-holders, and so forth.

WHAT IS CLAIMED IS:

1. A method for at least semi-automatically negotiating a relationship between at least a first party and a second party, the steps of the method being performed by a data processor, the method comprising the steps of:

(a) providing a first intention for the first party and a second intention for the second party, each of said first intention and said second intention featuring a plurality of components;

(b) exchanging at least one dispatch between the first party and the second party, said at least one dispatch including a reference to a value for at least one of said plurality of components;

(c) altering at least one of said first intention for the first party and said second intention for the second party according to said reference to said value in said at least one dispatch;

(d) comparing said first intention to said second intention; and

(e) if said first intention matches said second intention, determining the relationship according to said first intention and said second intention.

2. The method of claim 1, wherein said reference to said value is selected from the group consisting of an actual value, a request for a value from said second party, and a request to select a value from a set of values for said second party.

3. The method of claim 1, wherein step (c) is performed by merging at least a portion of said first intention and at least a portion of said second intention to form a merged intention, such that the relationship is defined according to said merged intention.

4. The method of claim 3, wherein only a portion of said first intention and only a portion of said second intention are merged to form the relationship.

5. The method of claim 3, wherein an entirety of said first intention and an entirety of said second intention are merged to form the relationship.

6. The method of claim 3, wherein said first intention and said second intention are incomplete, such that step (b) further comprises the steps of:

(i) defining at least one computational device for adding at least one suggested component to at least one intention;

(ii) executing said at least one computational device to obtain said suggested component; and

(iii) sending a message from the first party to the second party, said message including a suggested component according to said at least one computational device.

7. The method of claim 6, wherein said dispatch of step (b) also includes said first intention of said first party and is sent from said first party to said second party, such that said second party adds said suggested component to said merged intention.

8. The method of claim 7, wherein step (b) further comprises the step of:

(iv) determining by said second party whether to accept said suggested component.

9. The method of claim 7, wherein step (b) further comprises the step of:

(iv) providing a value for said suggested component by said second party.

10. The method of claim 3, wherein said first intention and said second intention are incomplete, such that step (b) further comprises the steps of:

(i) defining at least one computational device at the second party for adding at least one suggested component to at least one intention;

(ii) executing said at least one computational device to obtain said suggested component; and

(iii) sending a message from the second party to the first party, said

message including a suggested component according to said at least one computational device.

11. The method of claim 3, wherein step (b) further comprises the step of:

(i) providing a value for at least one component by said second party.

12. The method of claim 1, wherein said component also includes a constraint for restricting said value.

13. The method of claim 12, wherein said constraint determines that said value is not alterable.

14. The method of claim 12, wherein said constraint determines that said value is alterable, such that step (b) further comprises the step of sending a return message with a counter offer for altering said value of said at least one variable by at least one of the first party and the second party.

15. The method of claim 12, wherein step (c) further comprises the step of removing at least one constraint from at least one component.

16. The method of claim 1, wherein step (c) further comprises the step

of saving a state of each of said first intention and said second intention to form a previous state, before altering said first intention and said second intention, the method further comprising the step of:

(f) if said first intention does not match said second intention, returning said first intention and said second intention to said previous state.

17. The method of claim 1, the method further comprising the step of:

(f) if said first intention matches said second intention, notifying each party of acceptance of the relationship.

18. The method of claim 1, wherein said first intention and said second intention are each constructed as a first intention tree and a second intention tree, respectively, such that step (d) is performed by comparing said first tree to said second tree.

19. The method of claim 18, wherein step (c) is performed by merging at least a portion of said first tree and at least a portion of said second tree to form a merged tree, such that the relationship is defined according to said merged tree.

20. The method of claim 19, wherein only a portion of said first tree and only a portion of said second tree are merged to form the relationship.

21. The method of claim 19, wherein an entirety of said first tree and an entirety of said second tree are merged to form the relationship.

22. The method of claim 1, wherein each component is constructed from a set of shared classes for the first party and the second party.

23. The method of claim 1, wherein the relationship is determined as a contract, said contract featuring a plurality of intentions, such that steps (a)-(e) are performed for each of said plurality of intentions.

24. A system for at least semi-automatically negotiating a relationship, the system comprising:

(a) a plurality of party modules, including at least a first party module and a second party module, each party module featuring an intention for determining the relationship, said intention featuring a plurality of components to be determined for the relationship, such that a process of negotiation matches said intention of said first party module to said intention of said second party module; and

(b) a central server for at least initially connecting at least said first party module to at least said second party module for performing negotiations.

25. The system of claim 24, wherein at least said first party module features a plurality of intentions for negotiating with a plurality of parties.

26. The system of claim 25, wherein said central server further comprises a server party module for performing said negotiations on behalf of at least one party.

27. The system of claim 26, wherein only said server party module performs said negotiations on behalf of a plurality of parties.

28. The system of claim 25, wherein said central server further comprises a server party module for performing said negotiations on behalf of said central server as a broker.

29. The system of claim 25, wherein said party modules perform said negotiations and said central server only initially connects said first party module to said second party module.

30. The system of claim 25, wherein at least one party module features at least one computational device for generating a suggested alteration to said intention according to at least one rule, such that if said first intention does not match said second intention, said suggested alteration is generated by said at least

one computational device.

31. The system of claim 30, wherein at least one party module further features at least one computational device for determining if said suggested alteration is accepted.

32. A method for at least semi-automatically negotiating a relationship between at least a first party and a second party, the steps of the method being performed by a data processor, the method comprising the steps of:

(a) providing a first intention for the first party and a second intention for the second party, each of said first intention and said second intention featuring a plurality of components;

(b) providing at least one computational device for defining an additional component for at least one of the first and second parties;

(c) comparing said first intention to said second intention;

(d) if said first intention is different than said second intention, defining said additional component by said at least one computational device of the first party;

(e) sending at least one message from the first party to the second party, said at least one message including said additional component;

(f) determining if said additional component is accepted by the second party;

(g) if said additional component is accepted by the second party, adding said additional component to said first intention for the first party and to said second intention for the second party;

(h) repeating step (c) at least once; and

(i) if said first intention matches said second intention, determining the relationship according to said first intention and said second intention.

33. The method of claim 32, wherein steps (d) to (i) are repeated at least once.

34. For use in a system for at least semi-automatically negotiating a relationship between a first party and a second party, each of the first party and the second party having a first intention and a second intention, respectively, such that the relationship is negotiated by matching the first intention and the second intention, a device operated by at least one of the first party and the second party, the device comprising:

(a) an intention data structure for holding an intention;

(b) a negotiation control program for controlling a process of negotiation; and

(c) a unifier for unifying said intention data structure of a party with said intention data structure of another party to form the relationship.

35. The device of claim 34, wherein said intention data structure includes at least one constraint, the device further comprising:

(d) a constraint solver for solving said at least one constraint.

ABSTRACT OF THE DISCLOSURE

A system, method and device for (semi-)automated e-commerce on the Internet, the WWW and other networks. Trading parties present intentions, made of more elementary components, which are used to express their willingness to engage in deals subject to constraints. Parts of intentions may be variable components. Some variable components may be associated with computational devices that transform them, optionally communicating via messages, into more specified components. This mechanism encodes business rules. By fitting intentions, contracts are formed.

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Table 1: An assignment program

Instruction	Current Assignment
Initially	$a→2, $b→3, R(C,D)→{(1,3), (2,4)}
$b=5	$a→2, $b→5, R(C,D)→{(1,3), (2,4)}
SELECT * AS :Sa, :Sb FROM R;	The values of the columns of the first tuple returned by the query are assigned to $a and $b. $a→1, $b→3, R(C,D)→{(1,3), (2,4)}
Send $a	The active party sends the message "Send $a". The value returned by the passive party, say 8, is assigned to $a. $a→8, $b→3, R(C,D)→{(1,3), (2,4)}
Q = Choose n=1 from R Format Col[1].Name = C, Col[1].Type=Number, Col[2].Name=D, Col[2].type=Number	The active party sends the message "Choose...". The one tuple relation returned by the passive party is assigned to Q. $a→8, $b→3, R(C,D)→{(1,3), (2,4)}, Q(C,D)→{(2,.4)}

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Combined Declaration For Patent Application and Power of Attorney

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled SYSTEM AND METHOD FOR AUTOMATED CONTRACT FORMATION, the specification of which (check one) ☒ is attached hereto.
☐ was filed on as Application Serial No. and was amended on . I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed
NA (number)	(Country)	(Day, Month, Year Filed)	☐ Yes ☐ No
(number)	(Country)	(Day, Month, Year Filed)	☐ Yes ☐ No
(number)	(Country)	(Day, Month, Year Filed)	☐ Yes ☐ No

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States Application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

60/151,795 (Application Serial No.)	31-AUG-99 (Filing Date)	pending Status (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	Status (patented, pending, abandoned)

I hereby appoint the following attorneys, with full power of substitution, association, and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Mark M. Friedman Registration No. 33,883

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Attorney Docket 74/00
page 2 of 2

Continuation of Combined Declaration For Patent Application and Power of Attorney

I hereby further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statement may jeopardize the validity of the application of any patent issued thereon.

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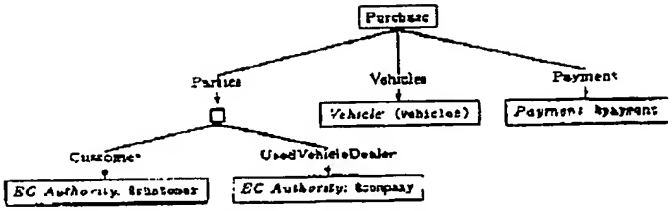
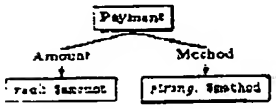
POST OFFICE ADDRESS		

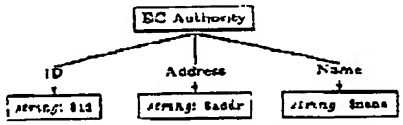
*FULL NAME OF SEVENTH INVENTOR	INVENTOR'S SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
	ISRAELI	
POST OFFICE ADDRESS		



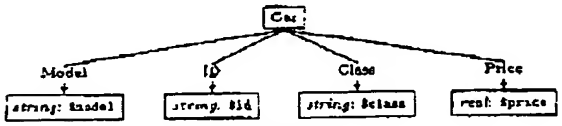
(a) The Purchase Contract Class



(b) The Payment Class

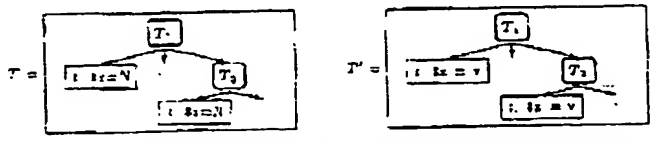


(c) The EC Authority Class

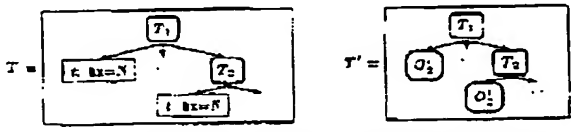


(d) The Car Class

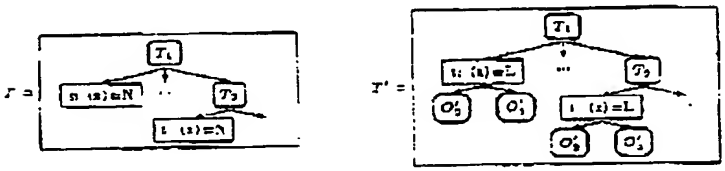
Figure 1: Examples of classes



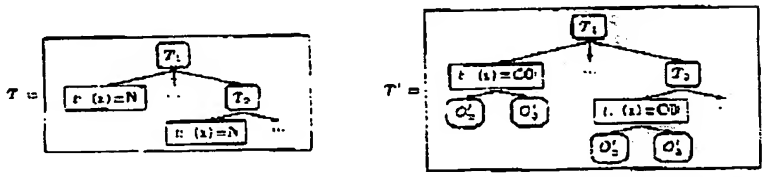
(a) T' is the tree resulting from the assignment of the atomic value v to the atomic variable $\$x$ in T.



(b) T' is the tree resulting from the assignment of the instance O'_2 of type t' to the class variable $\$x$ in T. In T', the root of O'_2 is labeled with the variable $(r: \$x = t')$

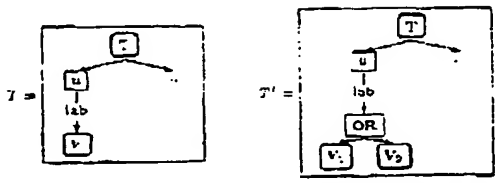


(c) T' is the tree resulting from the assignment of the list of instances $(O'_2.O'_3)$ to the class list variable (x) in T.

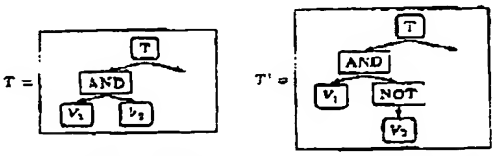


(d) T' is the tree resulting from the definition of the *list containment constraint* $(x) \supseteq (O'_2.O'_3)$ in T.

Figure 2: Variable instantiations



(a) T' is the result of adding an OR vertex to T — Note that V_1 and V_2 must be isomorphic to V up to renaming of variables. Adding an AND vertex is done in a similar way.



(b) T' is the result of adding a NOT vertex to T — Note that NOT vertices can be added only to subtrees rooted at an AND vertex.

Figure 3: Adding operator vertices

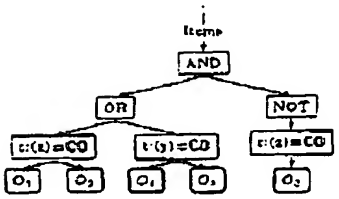
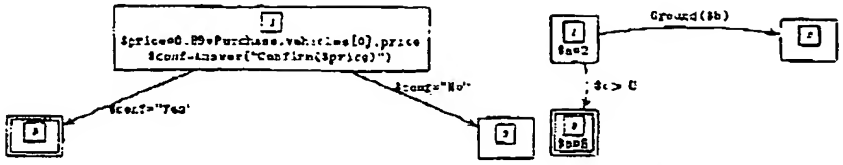
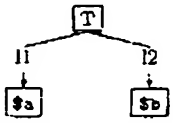


Figure 4: Using operator vertices

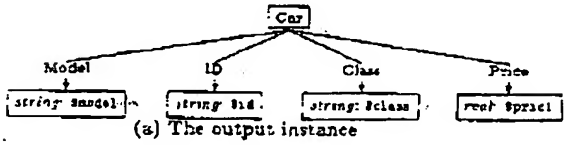


(a) Automaton APrice (b) Automaton B

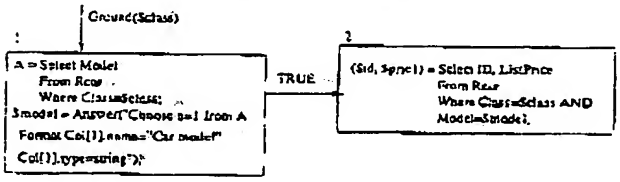


(c) The output instance (of class T) to be defined by Automaton B

Figure 5: Commerce automata - The final states have double frames



(a) The output instance



(b) The CA

Figure 6: The Acar CA

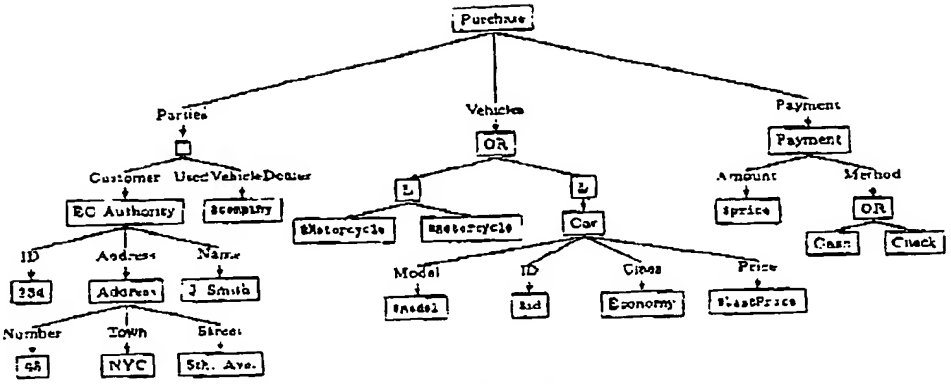


Figure 7: The customer's intention tree

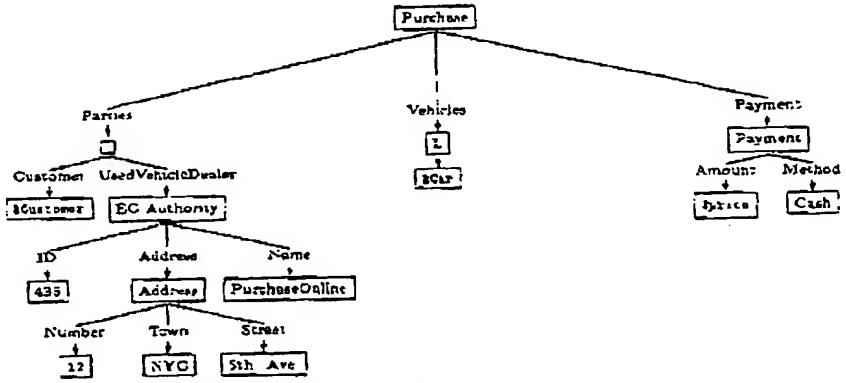


Figure 8: The used car dealer's intention tree

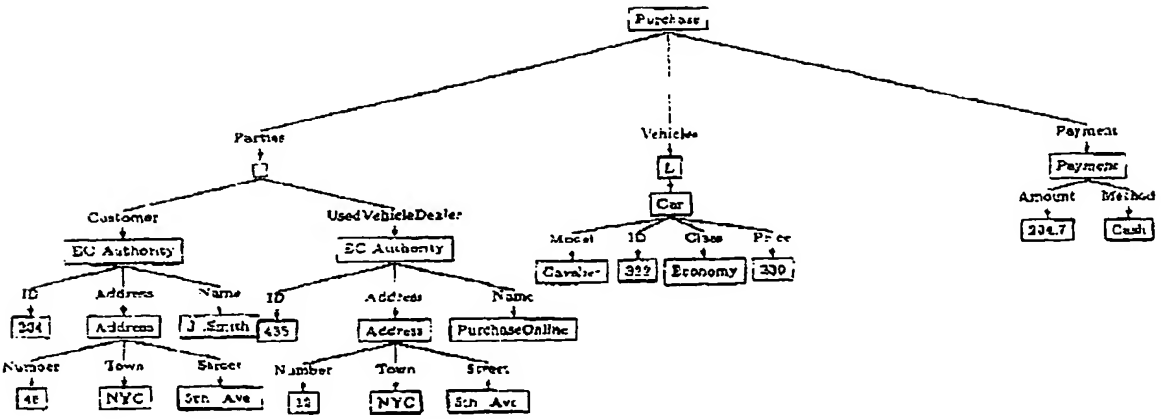


Figure 9: The generated EContract

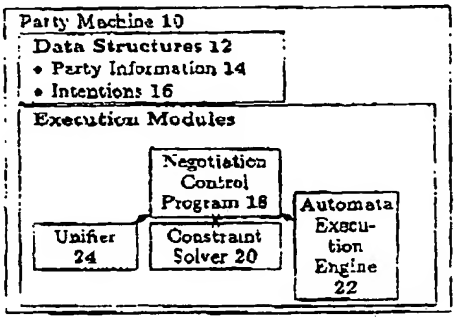


Figure 10: Party architecture

Figure 11

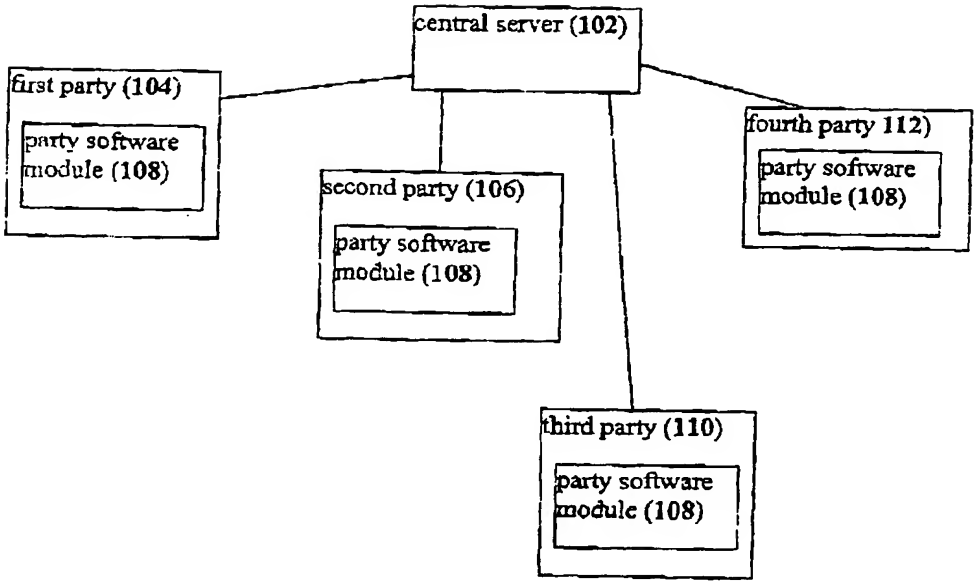
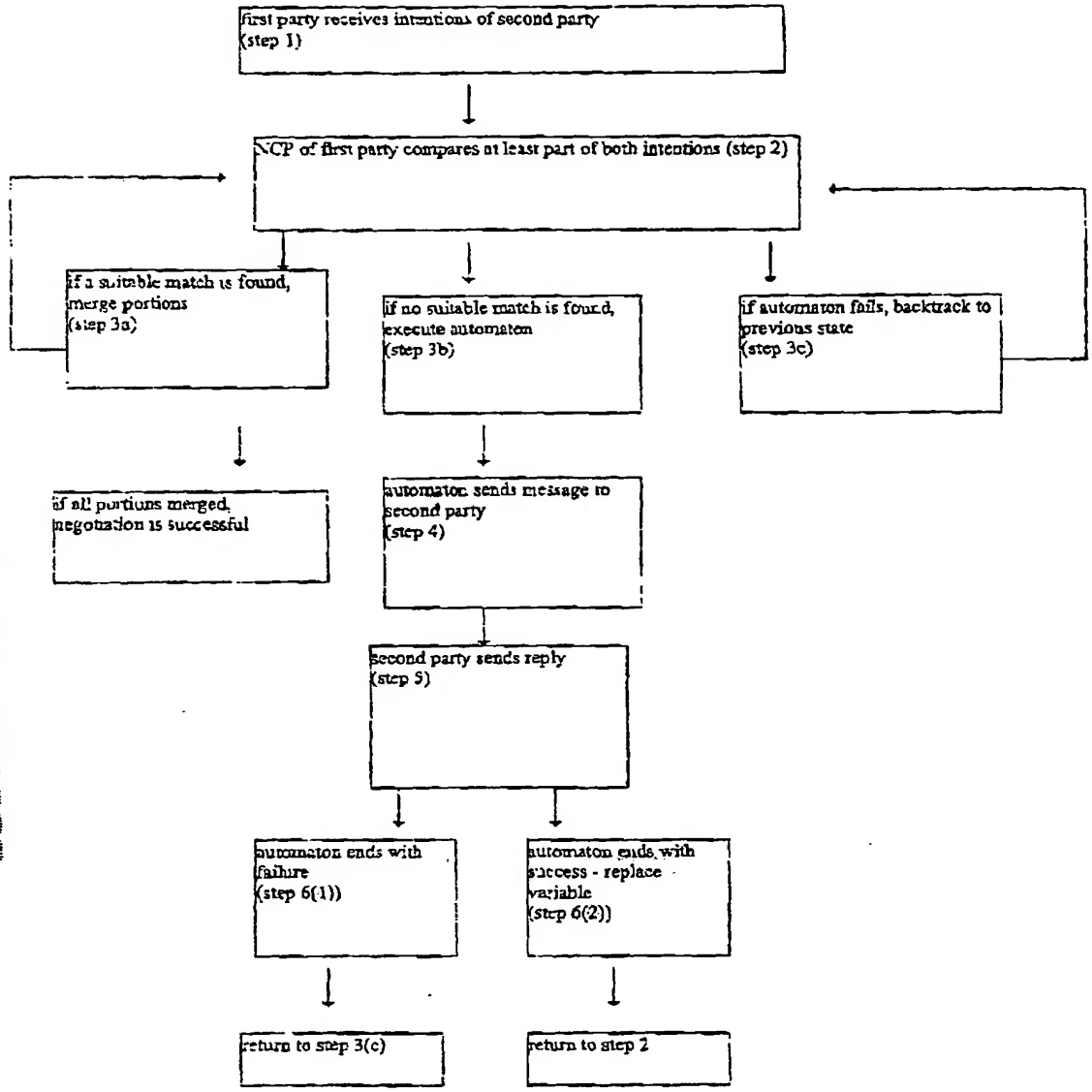

central server (102)
first party (104)
party software module (108)
second party (106)
party software module (108)
third party (110)
party software module (108)
fourth party 112)
party software module (108)

Figure 12


first party receives intentions of second party (step 1)
NCP of first party compares at least part of both intentions (step 2)
if a suitable match is found, merge portions (step 3a)
if no suitable match is found, execute automaton (step 3b)
if automaton fails, backtrack to previous state (step 3c)
if all portions merged, negotiation is successful
automaton sends message to second party (step 4)
second party sends reply (step 5)
automaton ends with failure (step 6(1))
automaton ends with success - replace variable (step 6(2))
return to step 3(c)
return to step 2

Appendix: Unification Algorithm

The input of the unification algorithm is two intention trees I1 and I2. C is the set of local constraints defined on I1 and I2. We assume that I1 and I2 do not contain OR vertices.

The algorithm is described in a Prolog-like language. We assume the existence of the following predicates:
- instance(T,S) Generates an isomorphic copy S of T with a disjoint set of variables including association to automata).
- var(V) Satisfied if V is an unbound variable.
- nonvar(V) Satisfied if V is not an unbound variable.
- atomic(V) Satisfied if V is an atomic variable.
- class(V) Satisfied if V is a class variable.
- int(V),float(V),string(V) Satisfied if V is ground and is an integer (float, string, resp.).
- mode(V,Structure,Type) Satisfied if variable V has the structure Structure (Structure can be: atomic, class or list) and type Type (Type can be: int, float, string or a class name).
- bassert(Edb) Backtractable assertion of the fact Edb.
- bretract(Edb) Backtractable retract of the fact Edb.
- classDesc(C1, C2) Class C1 is a descendant of class C2 in a class hierarchy of an ontology.
- automaton(V,A,O,ModeStmts) Satisfied if automaton A is assigned to V, its output instance is O and O's mode statements are ModeStmts.
- run(A,O) Execute automaton A on instance O.
- checkConstraints(T,C) Satisfied if the variables in T satisfy the constraints set C.
- permute([X1, ... Xn], [Y1, ... Yn]) Satisfied if (Y1, ... Yn) is a permutation of (X1, ... Xn). Backtracking generates the "next" permutation.
- ground(V) Satisfied if variable V has a non-null value.

The Unification Algorithm follows:

```
/* Main */
/* We assume that a fact (clause) is asserted prior to running the
unification, for each of the variables in the input intentions I1
and I2, in the following way:
assert(mode(variable name, structure, type)).*/

/* Run Unification; the result is I1. */
main_unification(I1,I2) <-- unify(I1,I2),
    checkConstraints(I1,C),write(I1).

/* Use symmetry. */
unify(I1,I2) <-- unify1(I1,I2).
unify(I1,I2) <-- unify1(I2,I1).
```

```
/* Unifying 2 Classes. */
unify1(T1,T2) <-- nonvar(T1), nonvar(T2),
   T1 = CN1(E1-C1, ..., Ek-Ck),
   /* CNi is class name, Ei is edge label to subtree Ci. */
   T2 = CN2(F1-D1, ..., Fk-Dk),
   class(CN1), class(CN2),
   CN1=CN2, E1=F1, ..., Ek=Fk,
   unify(C1,D1), ..., unify(Ck, Dk).

/* Unifying 2 Lists. */
unify1(T1,T2) <-- nonvar(T1), nonvar(T2),
   T1 = List(C1, . ., Ck), T2 = List(D1, ..., Dk),
   permute([C1, ..., Ck], [X1, ..., Xk]),
   unify(X1,D1), ..., unify(Xk, Dk).

/* Unifying a List and a superset constraint.*/
unify1(T1,T2) <-- nonvar(T1), nonvar(T2),
   T1 = List(C1, ..., Ck), T2 = CO(D1, . ., Dm),
   m<k, /* T1's elements must include T2's. */
   permute([C1. ..., Ck], [X1, ..., Xk]),
   unify(D1,X1), ..., unify(Dm, Xm).

/* Both T1 and T2 are rooted at a NOT vertex. */
/* There is no need to unify T1 and T2.*/
unify1(T1,T2) <-- nonvar(T1), nonvar(T2),
   T1 = NOT(ST1),
   T2 = NOT(ST2),
   !.

/* T1 is rooted at a NOT vertex. */
unify1(T1,T2) <-- nonvar(T1),
   T1 = NOT(ST1),
   not(unify(ST1,T2)).

/* T1 is rooted at an AND vertex */
unify1(T1,T2) <-- nonvar(T1),
   T1 = AND(ST1,ST2),
   unify(ST1,T2), unify(ST2,T2).

/* We only list rules for integer constants and variables. Similar
rules apply for the float and string atomic data types. */

/* 2 constants */
unify1(T1,T2) <--
    int(T1), int(T2), T1=T2.

/* Assigning a constant to a variable. */
```

```
unify1(T1,T2) <-- var(T1),
    mode(T1,atomic,int), int(T2),
    bretract(mode(T1,atomic,int)),
    T1=T2.

/* 2 atomic variables. */
unify1(T1,T2) <-- var(T1), var(T2),
    mode(T1,atomic,int),
    mode(T2,atomic,int),
    bretract(mode(T2,atomic,int)),
    T1=T2.

/* Assigning a class instance to a class variable. */
unify1(T1,T2) <-- var(T1), nonvar(T2),
    mode(T1,class,X),
    T2 = CN(E1-C1, ..., Ek-Ck), class(CN),
    classDesc(CN, X), /* CN is subclass of X. */
    bretract(mode(T1,class,X)),
    T1=T2.

/* 2 class variables. */
unify1(T1,T2) <-- var(T1), var(T2),
    mode(T1,class,X),
    mode(T2,class,Y),
    classDesc(Y, X),
    bretract(mode(T1,list,X)),
    T1=T2.

/* Assigning a list to a list variable. */
unify1(T1,T2) <-- var(T1), nonvar(T2),
    mode(T1,list,X),
    T2 = List(C1, ..., Ck),
    /* Need to check whether the list variable and the list's items have compatible types */
    bassert(mode(A1,Z1,X)), ...,
    bassert(mode(Ak,Zk,X)),
    unify(A1,C1), ..., unify(Ak, Ck),
    Z1<>list, ... , Zk <>list,
    bretract(mode(T1,list,X)),
    T1=T2.

/* A list variable and a superset constraint. */
unify1(T1,T2) <-- var(T1), nonvar(T2),
    mode(T1,list,X),
    T2 = CO(C1, ..., Ck),
    /* No unification is done, the constraint is noted */
    bassert(constraint(CO,T1,T2)).

/* 2 list variables. */
```

```
unify1(T1,T2) <-- var(T1), var(T2),
   mode(T1,list,X),
   mode(T2,list,Y),
   classDesc(Y, X),
   bretract(mode(T1,class,X)),
   T1=T2.

/* Unifying an automaton variable. */
unify1(T1,T2) <--
    automaton(T1,A,O,ModeStmts),
 bassert(ModeStmts), unify(O,T2), /* Prepare automaton ``inputs'' */
run(A,O),
/* We abstract by running the automaton in the same environment. when run remotely
we'll export part of the environment and then re-install a version of it, based on the
remote execution */
unify(O, T1 ).

/* Special case: unification of 2 superset constraints. */
unify1(T1,T2) <-- nonvar(T1), nonvar(T2),
    T1 = CO(C1, ..., Ck),
    T2 = CO(D1, ..., Dm),
    /* No unification is done, constraints are noted. */
    bassert(constraint(CO, T1, T2))
```

Note that if unbound variables appear in a subtree rooted at a NOT vertex, it is possible for the unification algorithm to fail while reaching an agreement was in fact possible. This problem arises because the unification order is fixed by Prolog and does not take into account that unification with subtrees rooted at NOT vertices may be done after all the relevant variable bindings are determined. In such a case, it is possible to modify the intention trees so that the standard order of unification leads to a correct result.